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PRELIMINARY MANUAL

GR 1689 Precision RLC Digibridge™

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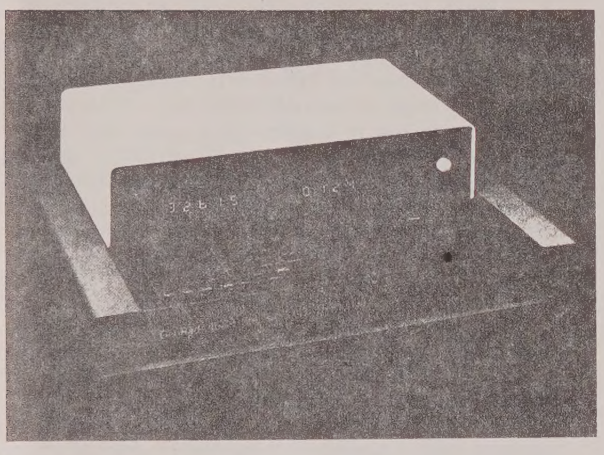

The GenRad 1689 Precision RLC Digibridge®

A low-cost, full performance, automatic RLC tester—that's the 1689 Digibridge® digital impedance meter. A programmable, microprocessor-based precision instrument, the 1689 offers component manufacturers and users the speed, frequency ranges, test voltages, and reliable operation characteristics required to test a wide spectrum of passive components under even the most demanding of test conditions.

Ideal for production test applications, the 1689 is also an excellent choice for: incoming inspection, component design and evaluation, process monitoring, and dielectric measurements. To meet the requirements of so many applications, the 1689 features:

- 0.02% basic accuracy for RLC measurements
- Programmable test frequencies (12 Hz to 100 KHz)
- Programmable test voltages (5 mV to 1.25 V)
- High measurement speeds (12 meas/sec standard, 20 meas/sec with high-speed option)
- IEEE bus/handler interface
- Wide measurement ranges
- Automatic limit comparison and binning (up to 15 bins)

Exceptional Accuracy for Unmatched Test Quality

Never before has an automatic bridge provided such high accuracy at such a low price. Its unequalled measurement accuracies—basic D accuracy of ± 0.0001, basic RLC accuracy of ± 0.02%—are made possible by a number of the 1689's special features.

The standard 1689 features a **built-in test fixture** that will accept radial or axial components. For components that cannot be physically inserted into the built-in test fixture, extender cables and a variety of accessories are available to enable the user to adapt to other components and fixtures. **Guarded Kelvin measurement techniques** are employed to eliminate the errors caused by series impedance or shunt admittances.

And with the 1689's **automatic zeroing** feature, stray fixture capacitance and conductance as well as series resistance and inductance are removed by a simple keyboard operation. With the test fixture first open-circuited and then short-circuited, "zero" values are established and stored by the unit's microprocessor for use as the "zero reference point" in subsequent measurements. The 1689 also automatically compensates for the drifts and offsets associated with active components in critical measurement circuits. This feature eliminates the need for time-consuming, periodic tweaking or setting of internal controls.

Performance is further enhanced by the 1689's **SPECIAL FUNCTION key** which allows you to select several special features including: direct range setting, range extension, choice of integration times, blanking of lesser digits, signal reversal to reduce hum pickup effects, selection of the median value of three measurements, and a routine that reduces transient delays when bias is applied.

With the 1689's **five full-digit LED readout,** you can take full advantage of its exceptional accuracy. A simple keyboard entry extends the D resolution to 1 PPM for measurement of low-loss film or mica capacitors and dielectric materials.

Self-check diagnostics put the 1689 through its paces whenever the unit is switched on. The entire operation takes just seconds, and if any of the diagnostic tests fail, the display guides the user to the problem.

Speed and Flexibility for Unequalled Test Capability

The 1689's unique features make it possible for you to handle an exceptionally broad range of test requirements.

Programmable test frequencies and test voltages mean that the 1689 is not limited to a few fixed frequencies or voltages. Both can be selected via the keyboard for a degree of flexibility afforded by no other instrument in this price range. You can choose any of over 500 frequencies between 12 Hz and 100 KHz, and test voltages can be selected from 5 mV to 1.25 V in 5 mV steps for effective coverage of all major specified test voltages.

High test speeds are critical in production test applications. The standard 1689 provides **higher test speeds** than most other general purpose instruments currently available. But the 1689 doesn't stop there. Outfitted with its **high-speed option,** this member of the GenRad Digibridge family is the highest speed benchtop RLC tester available, capable of making as many as 20 measurements per second—a speed suitable for even the most demanding component production application. In addition, a delay of from 1 to 99999 ms can be added to allow for settling of external switches and to permit an even wider selection of measurement rates.

For even greater test flexibility, the 1689 provides a choice of four different **display modes** for measurement results: VALUE, % difference, RLC difference,

and BIN NUMBER. The VALUE display can be one of four pairs of measured quantities: L and Q, C and D, C and R, or R and Q. The % difference display indicates the percent deviation of the measured L, C, or R value from a stored nominal value. The RLC difference is similar to the % difference but the deviation is displayed in the appropriate measurement units (e.g., ohms, henries, etc.). The BIN NUMBER displays a single digit indicating the number of the appropriate bin for sorting the component under test.

In addition, test frequency, test voltage, number of measurements averaged, delay time, nominal value, bin limits, and bin sum are displayed during entry or upon interrogation. The 1689's convenient GO/NO GO lights enable rapid error-free manual sorting as well.

The 1689 offers you a choice of **measurement modes**: CONTINUOUS and TRIGGERED. In the CONTINUOUS mode, successive measurements are made continuously and the display is updated after each measurement. In the TRIGGERED mode, measurements are initiated by the START button or remotely from either the IEEE bus or the handler interface; each measurement result is displayed until the next measurement is started. In both modes, you can display either the result of a single measurement or the average of up to 255 measurements.

The 1689 features **automatic sorting and binning.** On the standard 1689, components can be sorted in up to ten bins. When the high-speed option is added, components can automatically be sorted in up to fifteen bins. In both cases, the 1689 can automatically keep track of the number of components sorted into each bin.

The 1689's **keyboard lock** and **memory protection** features ensure the integrity of your tests. And with the IEEE bus/handler options you can connect the 1689 to device handlers, printers, or calculators.

Digibridge Ease of Use for Improved Productivity

Even with its higher level of performance, the 1689 is as easy to operate as the other members of the GenRad Digibridge family.

The **displays** are easy to switch, easy to read. Test speeds, equivalent series or parallel circuit modes, and test modes are chosen by pressing a single button. **Range selection** doesn't even require that much effort: it's fully automatic.

The 1689's **keyboard controls** for entering test limits, test frequencies, and test voltages are clear, simple, and straightforward to use.

The GenRad Digibridge Family for a Cost-Effective Choice

The 1689 Precision RLC Digibridge® is one of GenRad's family of automatic bridges that give you a choice of instruments for passive component testing. Each provides unmatched accuracy, flexibility, and ease of use in its class. You can choose the one that provides the capabilities your application requires, without being forced to pay for features that you may have no use for.

For more information on how the 1689 can improve your productivity, call GenRad's Digibridge Support Group today. Call toll-free 800-343-4470. (In Arizona, Washington, Oregon, and Colorado, call 800-538-9424. In California, call 408-727-0127, ext. 29. In Massachusetts, call 617-890-4900, ext. 378.)

1689 Specifications

Displays

Measurement results may be displayed in four ways as selected by the keyboard:

VALUE, % difference, RLC difference, and BIN NO.

The VALUE display can be one of four pairs of measured quantities L and Q, C and D, C and R, or R and Q. The primary display (L, C, or R) has five digits of resolution and the secondary display (D, Q, or R with C) has four digits of resolution.

The % difference display indicates the percent deviation of the measured L, C, or R value from a stored NOMINAL VALUE. The sign of this deviation is indicated.

The RLC difference is similar to the % difference except that the deviation is displayed in appropriate units (ohms, henries, etc.).

The BIN NO. display is the number of the bin (0 through 14) into which the component should be sorted. The testing limits for these bins are set up by the user in the ENTER mode. These test limits may be symmetrical or non-symmetrical about the NOMINAL VALUE. One bin is used for D or Q rejects and one is used for RLC rejects (outside all limits). The sum of the number of components sorted into each bin may be displayed (99999 max).

Also displayed during entry or upon interrogation are: test frequency, test voltage, number of measurements averaged, delay time, nominal value, bin limits and bin sum and codes for SPECIAL FUNCTIONS.

GO/NO-GO lights are also provided and these are active with all modes of measurement display as long as test limits have been set.

Ranges

Primary Display:

C: .0001 pF to 99999 μF
R: .00001 Ω to 99999 kΩ
L: .00001 mH to 99999 H
% difference (C, R, or L): .0001% to 99999%
RLC difference: same as R, L, or C

If any of these quantities is negative, the NEG RLC indicator light is lit.

These ranges may be extended. See SPECIAL FUNCTIONS below.

Secondary Display:

D (with C) or Q (with L or R): .0001 to 9999
D (with C) or Q (with R) in ppm: 1 ppm to 9999 ppm
R (with C): .0001 Ω to 9999 kΩ

If any of these quantities is negative, the NEG QDR indicator is lit.

Equivalent Circuit

Either the equivalent SERIES or the equivalent PARALLEL circuit representation of L, R, or C may be selected by keyboard control.

Test Frequencies

Over five hundred test frequencies between 12 Hz and 100 kHz may be selected using the keyboard. These are:

$$f = \frac{200\ kHz}{n} \quad \text{where } 2 \le n \le 13$$

$$f = \frac{60\ kHz}{n} \quad \text{where } 4 \le n \le 256$$

$$f = \frac{3\ kHz}{n} \quad \text{where } 13 \le n \le 250$$

If the exact frequency entered is not available, the nearest available frequency will be used. Frequency tolerance is .005%.

Test Time

The test rate is selected by the keyboard. The test time for a complete measurement with no range change is less than shown below (where f = frequency in kHz):

Test Rate	Continuous	Triggered
Slow	1030 ms	add 12 ms/f
Medium	240 ms + 7 ms/f	add 10 ms/f
Fast	95 ms + 8 ms/f	add 7 ms/f
Maximum	68 ms + 9 ms/f	add 7 ms/f

These test times are reduced by: 25 ms if the high-speed option is used; and by 10 ms if only the bin number is displayed (35 ms if both).

These times are increased by: 12 ms if IEEE bus output is used (either option).

The test connections may be broken and a new component connected before a measurement is complete as long as the data acquisition is over (ACQ line low). To determine this time, subtract 50 ms from the data in the table above.

An automatic range change takes one full measurement cycle. A range may be held using the RANGE HOLD key to ensure maximum test speed.

Measurement Modes

Two test modes are available: CONTINUOUS and TRIGGERED.

The CONTINUOUS mode makes successive measurements continuously, updating the display after each measurement.

TRIGGERED measurements are initiated by the START button, or remotely from the IEEE bus or from the Handler Interface, and the measurement result is displayed until the next measurement is started.

Average

The AVERAGE of any number of measurements from 1 to 255 may be made as desired in either of the two MEASURE MODES. In the TRIGGERED mode, the running average is displayed and the final value held until the START button is again depressed. In the CONTINUOUS mode, only the final value is displayed.

Test Voltage

The RMS test voltage is selectable from 5 mV to 1.25 V in 5 mV steps. The accuracy is 5% plus 2 mV. This voltage may be applied behind a source impedance (which depends on the range) in which case the selected voltage is the maximum that will be applied and the voltage will be less at the low impedance end of each range. The voltage may be applied also behind 25 ohms using the CONSTANT VOLTAGE function in which case the applied voltage will be constant except when low impedances are measured.

Delay

A delay of from 1 to 99999 ms may be added to allow for settling of external switches and to permit a wider selection of measurement rates.

DC Bias

An internal bias of 2 V may be applied to capacitors under test by means of the INT BIAS key.

An external bias of up to 60 VDC may be applied to capacitors under test using a panel switch. The applied current should be limited to 200 mA.

The instrument is protected from damage from charged capacitors with a stored energy up to 1 joule at 60 volts or less. Protection from higher voltages may be provided by external components.

Zeroing

Open: A simple OPEN operation removes the effects of stray capacitance and conductance of the internal test fixture or any other test fixture or cable.

Short: A similar SHORT zeroing operation removes the effects of series resistance and inductance.

DUT Connections

The instrument has a built-in test fixture that will accept radial or axial components. Four terminal (Kelvin) connections are made to the device under test. The instrument ground is guard for three-terminal measurements.

Keyboard Lock

A combination of keyboard entries makes the keyboard inactive.

Special Functions

Several special features may be selected. These include:

- Direct range setting
- Range extension
- Choice of integration time
- Blanking of lesser digits
- Signal Reversal to reduce hum pickup effects
- Selection of the median value of three measurements
- A routine that reduces transient delays when bias is applied
- Automatic parameter selection

IEEE-488 Bus/Handler Interface Card (1658-9610)

IEEE-488 Bus (J2 on rear panel with option)

All front panel functions are programmable from the bus. All RLC, DQ, and bin data are available as output to the bus.

The following functions, per IEEE-488, have been implemented:

AH1	Acceptor Handshake (Listener).
SH1	Source Handshake (Talker).
T5	Talker with normal and talk-only modes (for systems without a controller), switch selectable on rear panel.
L4	Listener.
SR1	Service Request (to request service when measurement is complete and the instrument is not addressed to talk).
RL2	Remote/Local (no local lockout, no return-to-local switch).
PP0	No parallel poll.
DC0	No device clear.
DT1	Device Trigger (to start measurement).
C0	No controller functions.

Handler Connections (J1 rear panel with option)

1. Outputs, Active low: (Open collector drivers rated at 30 V max. Each will sink 16 mA at 0.4 V. External power and pull-up resistors required).

   Bin 0 through bin 9 (10 lines) — Sorting outputs.

   ACQ OVER (1 line) — indicates end of data acquisition. Component may be removed (see TEST TIME).

   EOT (1 line) — indicates end of test. Bin No. is valid.

2. Input, Active low:
   (0 V < 1 V < 0.4 V, +2.5 V < Vh < +5 V)
   Start (1 line) — Initiates new measurement.

High-Speed Measurement/Interface Option (1689-9610)

Same as above option but also with high-speed capability to increase measurement rate and five more sorting bins (15 lines, open collector drives rated at 15 V max. Each will sink 24 mA at 0.5 V). See TEST RATE specification, above.

Limit of Error (Accuracy)

Primary Readout C, R, or L

$$C: \quad .01\% \left[(1+Kcv) \text{ or } \frac{Cx}{Cmax} \text{ or } \frac{Cmin}{Cx} \right] (1+|D|) \quad (1+Ks+Kfv) + .01\%$$

$$R: \quad .01\% \left[(1+Kcv) \text{ or } \frac{Rx}{Rmax} \text{ or } \frac{Rmin}{Rx} \right] (1+|Q|) \quad (1+Ks+Kfv) + .01\%$$

$$L: \quad .01\% \left[(1+Kcv) \text{ or } \frac{Lx}{Lmax} \text{ or } \frac{Lmin}{Lx} \right] \left(1+\frac{1}{|Q|}\right) (1+Ks+Kfv) + .01\%$$

NOTES:

1. The limit of error is a percent of the reading and may be positive or negative.
2. The largest term of the first bracketed factor should be used.
3. Cx, Rx, and Lx are the values of the components being tested, and Cmax, Cmin, Rmax, etc., are range constants given in Table I below.
4. The values of Ks, Kfv, and Kcv are all zero for measurements made at 1 kHz, with the SLOW measurement rate and using a non-CONSTANT 1 V signal.

   For other test conditions, these constants may be evaluated using Tables II through V below.
5. Although L measurements on the 1689 should be capable of the accuracy stated above, calibrations by the National Bureau of Standards are specified to .02% so that this amount should be added to the 1689 specification for inductance measurements if they are to be used in any manner involving legal certification.

Secondary Readout R with C

R (with C); $D \geq 1$:

$$1 \text{ count} + .01\% \left[(1+Kcv) \text{ or } \frac{Rx}{Rmax} \text{ or } \frac{Rmin}{Rx} \right] \left(1+\frac{1}{|D|}\right) (1+Ks+Kfv) + .01\%$$

R (with C); $D < 1$:

$$1 \text{ count} + .01\% \left[(1+Kcv) \text{ or } \frac{Cx}{Cmax} \text{ or } \frac{Cmin}{Cx} \right] \left(1+\frac{1}{|D|}\right) (1+Ks+Kfv) + .01\%$$

This is a percent of reading specification plus (or minus) 1 count because of resolution. Otherwise, the notes for the primary readout apply.

Secondary Readout D and Q

D (with C):

$$.0001 \left[(1+Kcv) \text{ or } \frac{Cx}{Cmax} \text{ or } \frac{Cmin}{Cx} \right] (1+|D|+D^2) \ (1+Ks+Kfv) + .0001$$

Q (with R):

$$.0001 \left[(1+Kcv) \text{ or } \frac{Rx}{Rmax} \text{ or } \frac{Rmin}{Rx} \right] (1+|Q|+Q^2) \ (1+Ks+Kfv) + .0001$$

Q (with L):

$$.0001 \left[(1+Kcv) \text{ or } \frac{Lx}{Lmax} \text{ or } \frac{Lmin}{Lx} \right] (1+|Q|+Q^2) \ (1+Ks+Kfv) + .0001$$

NOTES:

This is not a percent error but rather the amount, positive or negative, by which the D or Q reading may be in error. Otherwise, the notes for the primary readout apply.

When using DQ in PPM the final term of .0001 should be removed.

Environment

Operating: 0° to 50°C, 0 to 85% relative humidity.
Storage: −40° to 74°C.

When the high-speed option is used, the operating temperature range is 0° to 40°C.

Temperature Effects (typical)

R, L or C: ± 5 ppm/°C.
Q or D: ± [2 ppm/°C + (3 ppm/° C) × (frequency in kHz)]

All specifications refer to 23°C (calibration temperature).

Power

90 to 125 V or 180 to 250 V AC, 50 to 60 Hz.

Voltage selected by rear panel switch; 50 watts maximum, 40 watts typical. When the high-speed option is used, the maximum power is 60 watts.

Mechanical

DIMENSIONS (W × H × D): 14.781 × 4.40 × 13.50 in. (375.4 × 111.8 × 342.9 mm).
WEIGHT: 13 lbs. (5.9 kg).

Description	Catalog Number
1689 Precision RLC Digibridge®	1689-9700
1689 Precision RLC Digibridge® with IEEE/Handler Interface (1658-9610)	1689-9701
1689 Precision RLC Digibridge® with High-Speed Option and IEEE/Handler Interface (1689-9610)	1689-9702
IEEE/Handler Interface Option Retrofit	1658-9610
High-Speed Measurement and IEEE/Handler Option Retrofit	1689-9610

Table I
Range Constants

	AUTO RANGE	RANGE HELD			
		RANGE 1*	RANGE 2	RANGE 3	RANGE 4
Cmax	25 μF/f	6400 pF/f	100 nF/f	1600 nF/f	25 μF/f
Cmin	400 pF/f**	400 pF/f	6.4 nF/f	100 nF/f	1.6 μF/f
Rmax	410 KΩ	410 KΩ	25.6 KΩ	1.6 KΩ	100 Ω
Rmin	6.25 Ω	25.6 KΩ	1.6 KΩ	0.1 KΩ	6.25 Ω
Lmax	65 H/f**	65 H/f	4100 mH/f	256 mH/f	16 mH/f
Lmin	1 mH/f	4.1 H/f	256 mH/f	16 mH/f	1 mH/f

Where f = test frequency in kHz.
*This range is not used above 20 kHz.
**Above 20 kHz, Cmin = 6.4 nF/f and Lmax = 4100 mH/f.

Table II
Kcv as a Function of Voltage Mode (Constant Voltage)

Voltage Mode	Non-Constant	Constant Voltage
Kcv	0	3

Table III
Ks as a Function of Measurement Rate and Speed

Measurement Rate	Slow	Medium	Fast	Maximum*
Ks	0	3	13	23

*Set for 1 ms or 1 cycle integration time (SPECIAL function)

The information presented herein is subject to change and intended for general information only.

TABLE IV **
Kfv AS A FUNCTION OF FREQUENCY AND RMS VOLTAGE FOR RANGE 1
(HIGH IMPEDANCE)

Frequency - Voltage	12 to <30Hz	30 to <100Hz	100 to <250Hz	250 to <1000Hz	1KHz	>1 to 3 KHz	>3 to 6 KHz	>6 to 10KHz	>10 to 20 KHz	>20 to 50 KHz	>50 to 100KHz
1 to 1.26V	7	3	2	1	0	2	6	15	50		
.25 to <1V	9	5	3	2	1	3	10	20	65	THIS RANGE	
.1 to <.25V	12	8	6	5	4	6	15	30	100	IS NOT	
.03 to <.1V	35	30	25	20	15	17	25	50	*	USED ABOVE	
.01 to <.03V	90	80	70	60	50	50	60	80	*	20 KHZ	

* Not Specified

Accuracy not specified below 10mV.

TABLE V **
Kfv AS A FUNCTION OF FREQUENCY AND RMS VOLTAGE FOR RANGES 2, 3, AND 4

Frequency - Voltage	12 to <30Hz	30 to <100Hz	100 to <250Hz	250 to <1000Hz	1KHz	>1 to 3 KHz	>3 to 6 KHz	>6 to 10KHz	>10 to 20 KHz	>20 to 50 KHz	>50 to 100KHz
1 to 1.26V	7	3	2	1	0	1	2	3	5	15	30
.25 to <1V	9	5	3	2	1	2	3	5	6	18	35
.1 to <.25V	12	8	6	5	4	5	6	8	10	22	40
.03 to <.1V	35	30	25	20	14	15	15	15	20	30	50
.01 to <.03V	90	80	70	60	50	50	50	50	60	70	90

Accuracy not specified below 10mV.

Operation — Section 3

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3.1 BASIC PROCEDURE

3.1.1 General

For initial familiarization, follow this procedure carefully. After that, use this paragraph as a ready reference and refer to later paragraphs in this section for details.

Refer also to the Condensed Operating Instructions, found stored in a pocket under the instrument. Reach under the front edge and pull the card forward as far as it slides easily. After use, slide it back in the pocket for protection.

3.1.2 Startup

CAUTION

Set the line voltage switch properly (rear panel) before connecting the power cord.

This is the regular startup procedure.

a. After the line-voltage switch has been set to the position that corresponds to your power-line voltage (which must be in either range: 90 to 125 V or 180 to 250 V ac, nominally 50 or 60 Hz), then connect the power cord as explained below.

Temperature. If the Digibridge® has been very cold, warm it up in a dry environment, allowing time for the interior to reach 0 degrees C or above, before applying power. Otherwise, the Digibridge may require a complete recalibration

before it can be used.

Power Cord. Connect the power cord to the rear-panel connector, and then to your power receptacle.

b. If the Digibridge includes an optional IEEE-488 interface, set TALK switch (rear panel) to TALK ONLY (unless instructions are to be received through the IEEE-488 bus).

c. Switch EXTERNAL BIAS OFF (front panel).

d. Press the POWER button "in", so that it stays in the depressed position. Self-check codes will show briefly, indicating that the instrument is automatically executing a power-up routine that includes self checks.

(To turn the instrument off, push and release the POWER button and leave it in the "out" position.)

e. Wait until keyboard lights indicate MEASURE, VALUE, SLOW, CONT, SERIES. However, there are two possible exceptions to the norm: self-check fault and keyboard lock. If a fault is detected in the self-check, measurements are blocked and an error code remains displayed. (See paragraph 3.13.) If the keyboard is locked, all of the keyboard lights remain dark. To unlock it, see paragraph 3.9.

3.1.3 Zeroing

Before measurement, zero the Digibridge as follows. In this process, the Digibridge automatically measures stray parameters and retains the data, which it uses to correct measurements so that results represent parameters of the DUT alone, without (for example) test-fixture or adaptor capacitance.

a. Open Circuit.
- o Press [FUNCTION] key (if necessary) to select MEASURE mode.
- o Press [MEASURE MODE] key to select TRIGGERED mode.
- o If any test-fixture adaptors are to be used, install and position them for use. (See paragraph 3.2.)
- o Be sure that the test fixture is open circuited. (See footnote.*)
- o Press these keys: [1] [6] [8] [9] [=] [SHIFT] [OPEN].
- o Keep hands and objects at least 10 cm (4 in.) from test fixture.
- o Press the START button.
- o Wait for the GO light.

b. Short Circuit.
- o Short the fixture with a clean copper wire (AWG 18 to 30).
- o Press these keys: [1] [6] [8] [9] [=] [SHIFT] [SHORT].
- o Press the START button.
- o Wait for the GO light.
- o Remove the short circuit.

Note: For best accuracy, repeat this procedure every day and after any change of test-fixture adaptors.

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* If you want the following "zero" process to echo a display of 00000, press the [Cs/Cp] key. However, doing so will disable automatic parameter selection. (See paragraph 3.1.4, step b.)

3.1.4 Routine Measurement

a. Verify or select measurement conditions as follows (indicated by keyboard lights); press the adjacent key to change a selection.

- o Function: MEASURE ([FUNCTION] key), a necessary selection
- o Display: VALUE ([DISPLAY] key), for normal RLC/QDR results
- o Measure rate: SLOW ([MEASURE RATE] key), for best accuracy
- o Measure mode: TRIGGERED ([MEASURE MODE] key), optional
- o Equivalent circuit: SERIES ([EQUIVALENT CIRCUIT] key) -- see paragraph 3.3.

If you are in doubt about how to connect the device to be tested with the Digibridge, refer to paragraph 3.2, below. The following steps assume some familiarity with it.

b. To measure any passive component (without knowing whether it is essentially a resistor, inductor, or capacitor), use "automatic parameter selection". This feature is provided at power-up and remains enabled as long as you do NOT select any particular parameter. (Automatic parameter selection can be disabled by pressing the Cs/D key, for example. Once disabled, this feature can be enabled again by pressing these keys: [1][=][SHIFT][SPECIAL][7].) Place DUT in test fixture. Press START. The RLC display and units indicator show the principal measured value and the basic parameter, thus identifying the DUT. The QDR display shows the measured Q if the principal units are ohms or henries; the measured D if they are farads.

In steps c, d, e, f, the parameters to be measured are specified by the user.

c. To measure C and D of a Capacitor (C Range .0001 pF to 99999 uF, D range .0001 to 9999): Press [Cs/D]. Place capacitor in test fixture. Press START.
The RLC display shows Cs (series capacitance) and units (uF, nF, pF);
the QDR display shows D (dissipation factor).
{If "NEG RLC" is lit, DUT is inductive.}

d. To measure C and R of a Capacitor (C Range .00001 nF to 99999 uF, R range .0001 ohm to 9999 kilohm): Press [Cs/Rs]. Place capacitor in test fixture. Press START.
The RLC display shows Cs (series capacitance) and units (uF, nF);
the QDR display shows Rs (equivalent series resistance) and units (ohms, kilohms).
{If "NEG RLC" is lit, DUT is inductive.}

e. To measure L and Q of an Inductor (L range .00001 mH to 99999 H, Q range .0001 to 9999): Press [Ls/Q]. Place inductor in test fixture. Press START.
The RLC display shows Ls (series inductance) and units (mH, H);
the QDR display shows Q (quality factor).
{If "NEG RLC" is lit, DUT is capacitive.}

f. To measure R and Q of a Resistor (R range .00001 ohm to 99999 kilohms, Q range .0001 to 9999): Press [Rs/Q]. Place resistor in test fixture. Press START.
The RLC display shows Rs (series resistance) and units (ohms, kilohms);
the QDR display shows Q (quality factor).
{If "NEG QDR" is lit, DUT is capacitive; if dark, DUT is inductive.}

NOTE: This procedure is basic; there are many alternatives described later. You can select and program for other parameters, equivalent circuits, types of results displayed, test conditions, measurement rate, and bin sorting, to mention a few.

3.2 CONNECTING THE DUT

3.2.1 General

WARNING

Charged capacitors can be dangerous, even lethal. Never handle them if they have been charged to more than 60 V.

Routine discharging procedures may not be perfectly dependable. If high-voltage testing is necessary, schedule it to be done AFTER measurements on the Digibridge.

Connect a typical device, whose impedance is to be measured, as follows. (This "device under test" is often called the DUT.)

NOTE

Clean the leads of the DUT if they are noticeably dirty, even though the test-fixture contacts will usually bite through a film of wax to provide adequate connections.

3.2.2 Using the Integral Test Fixture for Radial-Lead DUTs

If the DUT is a radial-lead component or has parallel leads at one side, insert them into the Digibridge test-fixture slots as described below.

The test fixture provided on the front ledge of the Digibridge provides convenient, reliable, guarded 4-terminal connection to any common radial-lead or (with adaptors) an axial-lead component part.

The slots in the test fixture accommodate wires of any diameter from 0.25 mm (.01 in., AWG 30) to 1 mm (.04 in., AWG 18), spaced from 4 to 98 mm apart (0.16 to 3.9 in.) or equivalent strip conductors. Each "radial" wire must be at least 4 mm long (0.16 in.). The divider between the test slots contains a shield, at guard potential, with its edges semi-exposed.

NOTE

If any of the adaptors, described below, are in place, remove them before attempting to insert the DUT. The adaptors described next below should be removed by a gentle pull upward, made easier by bending the adaptor left or right.

3.2.3 Using the Test-Fixture Adaptors for Axial-Lead DUTs

If the DUT is an axial-lead component or has leads at oposite ends, insert the leads into the Digibridge test-fixture slots as described below.

Install the test-fixture adaptors, supplied, as shown; put one in each slot of the test fixture, by pushing vertically downward. Slide the adaptors together or apart so the body of the DUT will fit easily between them.

Notice that the contacts inside the adaptor are off center; be sure to orient the adaptors so the contacts are close to the body of the DUT, especially if it has short or fragile leads.

The adaptors accommodate wires of any diameter up to 1.5 mm (.06 in., AWG 15). The body of the DUT that will fit between these adaptors can be 80 mm long and 44 mm diameter (3.1 x 1.7 in.) maximum. Each "axial" wire must be at least 3 mm long (0.12 in.). The overall length of the DUT, including the axial wires must be at least 22 mm (0.866 in.).

Insert the DUT so one lead makes connection on the left side of the test fixture, the other lead on the right side. Insertion and removal are smooth, easy operations and connections are reliable if leads are reasonably clean and straight. Press the DUT down so that the leads enter the slots in the adaptors as far as they go easily.

Be sure to remove any obvious dirt from leads before inserting them. The test-fixture contacts will wipe through a film of wax, but will become clogged and ineffectual if you are careless about cleanliness. Be sure the contact pair inside each half of the test fixture is held open by a single item ONLY, whether that is one lead of an axial-lead DUT or one adaptor. (Otherwise you will not obtain true "Kelvin" connections to the DUT.)

NOTE

For a DUT with very short leads, it is important to orient each adaptor so that its internal contacts (which are off center) are close to the DUT. To remove each adaptor, lift with a gentle tilt left or right (never forward or back).

3.2.4 Using Adaptors and Cable for Remote Test Fixturing

Connection of the DUT at a remote test fixture requires proper adapters and cable connections from the Digibridge. Obtain the following accessories:

- o BNC Adaptor 1689-9601
- o BNC Cable Assembly 1689-9602
- o Remote Test Fixture 1689-9600

a. Remove any adaptors, if present, from the test fixture. Plug the BNC acaptor into the basic test fixture and lock the connection with the 2 captive thumb screws. (The screws must be seated to complete the ground connection.)

b. Connect the cable assembly to the adaptor on the Digibridge and to the remote test fixture as follows:

Connector at Digibridge	Cable Color	Connector at Remote Test Fixture	Test-Circuit Function	Bias Polarity
Left	Red	Left	Il (current, low)	+
Left-center	Red/white	Left-center	Pl (potential, low)	+
Right-center	Black/white	Right-center	Ph (potential, high)	-
Right	Black	Right	Ih (current, high)	-

c. Before making measurements, be sure to repeat the zeroing procedure (open circuit and short circuit), as described in paragraph 3.1.3.

3.2.5 The "874" Extender Cable

The accessory extender cable 1688-9600 to connect any DUT that is multiterminal, physically large, or otherwise unsuited for the built-in test fixture. This cable is needed, for example, to connect impedance standards or a special test fixture. Make connections as follows.

Using the branched end of the cable, connect to the DUT with careful attention to the following color code.

The cable tips are GR874(R) coaxial connectors, which mate with a broad line of components and adaptors. Notice that the 2 wires with red must connect to the same end of the DUT, through a coaxial tee if the DUT is a 2-terminal device; the 2 with black, to the other end, similarly.

EXTENDER CABLE COLOR CODE

RED AND RED: I+, current drive to "high" end of DUT.
RED AND WHITE: P+, potential connection to same.
BLACK AND BLACK: I-, current return at DUT "low".
BLACK AND WHITE: P-, potential connection to same.
OUTER CONTACTS: G, guard connection to shield or case (if isolated from the preceding terminals). Do not connect G to the shield or case if it serves as (or is connected to) one of the 2 main terminals.

Correction for Cable and Fixture Capacitances. Any test fixture extension cable adds a bit of capacitance in parallel with the DUT (because shielding of the leads is imperfect) and more between each terminal and ground. The recommended accessories can be accommodated by the Digibridge; i.e., the zero calibration process will compensate fully for the presence of the cable and adaptors (with the optional addition of tees to the 1688-9600), so that the instrument will measure to specified accuracy.

However, any other extension, such as longer cables and/or special remote test fixtures will probably affect measurement accuracy of very-high-impedance DUTs at high frequencies. It is important to use very low-capacitance shielded wire for

cables, not only for accuracy, but also to minimize resonance effects in the measurement of large inductance at high frequency.

Be sure to repeat either the entire power-up procedure or at least the open-circuit and short-circuit zeroing procedure after any change in test fixtures or their cable connections.

3.3 SELECTING PARAMETERS AND TYPE OF RESULTS

3.3.1 Parameters (R/Q, L/Q, C/D, C/R)

Selection of the parameter to be measured is almost self-explanatory.

a. Press one of the 4 parameter keys: (R/Q, L/Q, C/D, C/R).

b. Use the [EQUIVALENT CIRCUIT] key to select SERIES or PARALLEL. Note: When you select SERIES equivalent ckt, the 4 keys obtain Rs/Q, Ls/Q, Cs/D and Cs/Rs. When you select PARALLEL equiv ckt, the 4 keys obtain Rp/Q, Lp/Q, Cp/D and Cp/Rp.

Note: equivalent ciruits are discussed below, in paragraph 3.3.2.

For an inductor select L/Q; for a capacitor, either C/D or C/R; for a resistor, R/Q. There will be an immediate confirmation on the display panel, where appropriate units will be lighted. (However, do not attempt to select the unit multiplier.) The Digibridge will automatically switch to the appropriate multiplier -- from nF to pF for example --, unless RANGE is HELD, when it makes a measurement. The result will be displayed in terms of the parameters and equivalent circuit that you select, (even if the DUT has the opposite kind of reactance -- see below).

Note: displays are discussed below, in paragraph 3.3.3.

If the NEG RLC indicator on the main display panel is lighted with an L or C value displayed, the DUT reactance is opposite to the selected parameter. Although the displayed negative C or L is mathematically correct, it is relatively useless. As a rule, you should change parameter (usually select L instead of C or vice versa) so that a positive L or C value display can be obtained. Notice that the appearance of a device can be misleading. (For example, a faulty inductor can be essentially capacitive or resistive; a component part can be mislabeled or unlabeled.)

Avoid incorrect choice of parameter by watching for the NEG RLC indicator on the display panel. If this light is on, when the display is VALUE or BIN No., the principal parameter (L or C) was selected incorrectly. Try the oposite choice. However a negative indication when the display is delta% or deltaRLC means that the measured value is less than the reference (stored nominal value), and the parameter is probably correct.

Notice the NEG QDR indicator. It has the following meanings.

Parameter Selection	NEG QDR dark	NEG QDR lit
R/Q	DUT is inductive	DUT is capacitive
L/Q, C/D, or C/R	Q, D, or R is positive	Q, D, or R is negative (see below)

If Q, D, or R (as calculated by the Digibridge) is negative, there are two likely possibilities. If the QDR value is very small, the combination of calibration error and measurement error can lead to a negative result. Measurement error can be reduced by choice of measurement conditions, averaging, etc. Another possibility is that the DUT (as seen by the Digibridge) really does have a negative loss factor. This situation might be true of certain kinds of multiterminal network or an active device. It might be simulated (although not true) by some unusual connection of the cables normally used to provide for a remote test fixture.

3.3.2 Equivalent Circuits — Series, Parallel

The values of the principal measurement (R, L or C) and the secondary measurement (Q, D or R) of a certain DUT depend on which of two equivalent circuits is chosen to represent it -- series or parallel. (Many impedance measuring instruments provide no choice in the matter, but this one allows selection).

The more nearly "pure" the resistance or reactance, the more nearly identical are the "series" and "parallel" values. However, for D or Q near unity, the difference is substantial. Also, the measured component values often depend on measurement frequency. The more nearly "pure" the resistance or reactance, the less is this dependence. However, for D or Q near unity and/or for measuring frequency near the self-resonant frequency of the DUT, this dependence is quite substantial. We first give general rules for selection of measurement parameters, then some of the theory.

Making the Selection. The power-up selection is "series", confirmed by the SERIES indicator being lit, on the keyboard. To change the selection, press the [EQUIVALENT CIRCUIT] key.

Specifications. The manufacturer or principal user of the DUT probably specifies how to measure it. (Usually "series" is specified). Refer also to the applicable MIL or EIA specifications. Select "parallel" or "series" and the test frequency according to the applicable specifications. If there are none known, be sure to specify with your results whether they are "parallel" or "series" and what the measurement frequency was.

Capacitors less than 100 pF: Series or Parallel, 10 kHz.
Capacitors between 100 pF and 1 uF: Series, 1 kHz.
Capacitors greater than 1 uF: Series, 0.1 or 0.12 kHz. Unless otherwise specified or for special reasons, always select "series" for capacitors and inductors. This has traditionally been standard practice. For very small (large) capacitance, select a higher (lower) measurement frequency for best accuracy. (Refer to para 3.6.)

Inductors less than 10 uH: Series, 100 kHz.
Inductors between 10 uH and 1 mH: Series, 10 kHz.
Inductors between 1 mH and 1 H: Series, 1 kHz.
Inductors greater than 1 H: Series, 0.1 kHz. Select "series" as explained above. For very small (large) inductance, select a higher (lower) measurement frequency for best accuracy.

Resistors, below about 1 kilohm: Series, 1 kHz. Usually the specifications call for dc resistance, so select a low test frequency to minimize ac losses. Select "series" because the reactive component most likely to be present in a low resistance

resistor is series inductance, which has no effect on the measurement of series R. If the Q is less than 0.1, the measured Rs is probably very close to the dc resistance.

Larger Resistors. Between 1 kilohm and 10 megohms: Parallel, 0.250 kHz. Resistors greater than 10 megohms: Parallel, 0.030 kHz. As explained above, select a low test frequency. Select "parallel" because the reactive component most likely to be present in a high-resistance resistor is shunt capacitance, which has no effect on the measurement of parallel R. If the D is greater than 10, the measured Rp is probably very close to the dc resistance.

Series and Parallel Parameters.

An impedance that is neither pure reactance nor a pure resistance can be represented at any specific frequency by either a series or a parallel combination of resistance and reactance. Keeping this concept in mind will be valuable in operation of the instrument and interpreting its measurements. The values of resistance and reactance used in the equivalent circuit depend on whether a series or parallel combination is used. Notice that the Digibridge measures only the equivalent series components Rs, Ls, or Cs, if you select SERIES EQUIVALENT CIRCUIT. It measures only the parallel equivalent components Rp, Lp, or Cp if you select PARALLEL. D and Q have the same value regardless whether series or parallel equivalent circuit is calculated.

ESR for Capacitors. The total loss of a capacitor can be expressed in several ways, including D and "ESR", which stands for "equivalent series resistance" and which is designated "Rs" in the preceding paragraph. To obtain ESR, one can measure directly; push the [Cs/Rs] parameter key and be sure that the SERIES indicator is lit.

"Equivalent series resistance" is typically much larger than the "actual ohmic series resistance" of the wire leads and foils that are physcially in series with the heart of a capacitor. ESR includes also the effect of dielectric loss and is therefore dependent on frequency. ESR (i.e., Rs) is related to D by the formula $Rs = D/wCs$ (where w represents "omega", 2 pi times frequency).

Parallel Equivalent Circuits for Inductors. Even though it is customary to measure series inductance of inductors, there are situations in which the parallel equivalent circuit better represents the physical device. At low frequencies, the significant loss mechanism is usually "ohmic" or "copper loss" in the wire; and the series circuit is appropriate. If there is an iron core, at higher frequencies the significant loss mechanism may be "core loss" (caused by eddy currents and hysteresis); and the parallel equivalent circuit is appropriate. Whether this is true at any particular frequency should be determined by an understanding of the DUT, but probably it is so if the following is true: that measurements of Lp at 2 frequencies near the frequency of interest are more nearly in agreement than measurements of Ls at the same 2 frequencies.

3.3.3 Results

VALUE, Selected by the [DISPLAY] Key. The normal measurement, and the most commonly used, provides two displays: the principal one is RLC (resistance, inductance, or capacitance) and the secondary one is QDR (quality factor, dissipation factor, or resistance of a reactor). This selection is the power-up default and one of the selections of the [DISPLAY] key.

Read the measurement on the main displays. The RLC display is the principal measurement, complete with decimal point and units which are indicated by the light spot in the lower part of the display panel. The QDR display is Q if the selected parameter is R/Q or L/Q; it is D for C/D, or resistance (with units indicated) for C/R. Leading zeroes before the decimal point are automatically eliminated in most cases by positioning of the decimal point. Otherwise, such zeroes are blanked out.

DQ in PPM, Selected by the [SHIFT][DQ in PPM] Keys. This causes the QDR display to be expanded by the factor 1 000 000. For example, if the displayed D of a capacitor is .0001, changing to DQ in PPM might reveal that the D is really 138 ppm.

The "DQ in PPM" selection applies to the QDR result only, and is effective for all selections of the [DISPLAY] key except BIN NO, and for all parameter selections except C/R. When this selection is in effect, the DQ IN PPM indicator on the display panel is lit. To cancel this selection, use the same keystrokes again.

Delta Percent Displays, Selected by the [DISPLAY] Key. Presents the principal measurement (RLC) in terms of a percent difference above or below the nominal value last entered (i.e., a previously stored reference). If you wish to use this capability simultaneously with bin sorting, enter the bin limits first, as described above. Then (unless the last setting of nominal value happens to be the desired reference for percent difference) use the following simple procedure.

a. Select ENTER with the [FUNCTION] key.

b. Select appropriate parameter and units with [EQUIVALENT CIRCUIT] and [R/Q, L/Q, C/D, or C/R] key. (Repeat keying will change unit multipliers.)

c. Enter the reference for delta percent by keying:
(Y)[=][NOM VALUE]

in which Y represents 1 to 6 numerical keys and (optionally) the decimal point key, depressed in sequence. Confirmation is shown on the RLC display.

d. Select MEASURE with the [FUNCTION] key and delta% with the [DISPLAY] key.

e. Observe that the RLC display will now be in percent, not an electrical measurement unit.

Delta RLC Display, Selected by the [DISPLAY] Key. This selection is indicated by lighting BOTH indicators together: VALUE and delta%. The deltaRLC display is a difference, measured in the indicated electrical unit, such as ohms, millihenries, or picofarads. The procedure for selecting deltaRLC displays is similar to the delta% procedure, above.

Value, Delta, Bin, and Go/No-Go Displays

The Digibridge measurement will be presented on the display panel in one of four ways; VALUE, deltaRLC, delta%, or BIN No., (only one way for any single measurement). Exactly "when" you select the type of display is unimportant for most measurements, using MEASURE function and CONT mode. But for TRIGGERED-mode measurements, select the desired display before pushing START.

Value. Select VALUE with the [DISPLAY] key. When measurement is completed, the value will be shown on the RLC and QDR displays.

Delta Percent. Alternatively, select delta%. After measurement, the RLC display will be difference from the stored reference, as percent of that reference, with the NEG RLC indicator lit if measured value is less than reference. (The principal measurement result is shown on QDR area of display, for either delta% or VALUE selection.)

Delta RLC. Alternatively, select deltaRLC, by pressing the [DISPLAY] key repeatedly, until both the VALUE and the delta% indicators are lit. After measurement, the RLC display will be difference from the stored reference, in the units of the principal measurement, with the NEG RLC indicator lit if measured value is less than reference. (The principal measurement result is shown on QDR area of display, for either deltaRLC or VALUE selection.)

Bin. Alternatively, select BIN No., using the [DISPLAY] key. When measurement is completed, the bin assignment will be shown on the RLC display (a single digit), with the following significance:

0 = No-Go because of the secondary (QDR) limit
1 = Go, bin 1
2 = Go, bin 2
... Go, bin 3, 4, 5, ... 12, or 13, as indicated.
14 = No-go by default (suits no other bin).

GO/NO-GO. If comparison is enabled, by a non-zero entry for "nominal value", and limits in at least one bin, a GO or NO-GO indication is provided for every measurement. (The display selection can be whatever you choose.). GO means the measurement falls in bin 1 thru 13; NO-GO means bin 0 or 14.

3.3.4 Units, Multipliers, and Blank Displays

Units are determined entirely by your selection of parameter. Units multipliers are fixed by parameter and range, see Table 3-1, except that selection of delta% changes the RLC display to a percentage. Units of D and Q are dimensionless and are expressed as a decimal ratio, without multiplier -- unless you select "DQ in PPM", in which case D is expressed in parts per million.

Table 3-1
UNITS AND MULTIPLIERS FOR EACH RANGE

Freq:	Up to 0.1 kHz				From 0.1 to 6				From 6+ to 20				Above 20 kHz			
Range:	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Parameter																
R	K	K	ohm	ohm	K	K	ohm	ohm	K	K	ohm	ohm	*	K	ohm	ohm
L	H	H	H	mH	H	H	mH	mH	H	mH	mH	mH	*	mH	mH	mH
C/D	nF	nF	uF	uF	pF	nF	nF	uF	pF	nF	nF	nF	*	pF	nF	nF
C/R **	nF	nF	uF	uF	nF	nF	nF	uF	nF	nF	nF	uF	*	nF	nF	uF

* Range 1 is not used if frequency is above 20 kHz.
** For C in nF, R is in kilohms. For C in uF, R is in ohms.

Decimal Point Position. The decimal point is automatically positioned for maximum resolution (i.e., so that the first significant digit or the first zero after the decimal point is in the first position in the display) with a few exceptions, as listed below. Of course, displays on low underrange or low extension of a held range may have a number of necessary zeros to right of the decimal point (and therefore reduced number of significant digits compared to the display area) because units and multipliers are fixed on any one range. The above-mentioned exceptions are:

1. DQ in PPM is always displayed without a decimal point, in ppm.
2. Delta% displays can resolve no less than 0.0001% (i.e., 1 ppm).
3. Hysteresis is provided to reduce flickering, as explained below.

If the first digit of the measurement is 9, the decimal point for any measured-value display is left unchanged from its previous position, provided that so doing places that 9 in either the first or second position in the display area. (Notice that a number like 09XXX has resolution almost as fine as a number like 10XXX.)

For example, if the measured value is 99.985 nF, the display is a full 5 digits if the previous measured-value display was 12.345, 99.984, or 99.999; but the display is rounded off to 099.98 nF if the previous measured-value display was 100.02 or 1234.5 nF. Hysteresis is provided on both measured-value displays (RLC and QDR).

Blanks in Measured-Value Displays. If a measurement exceeds the capability of the display (all 9's), the display is blank. If a measurement is less than 1 right-hand digit, the display is all zeros. If any leading zero, before the decimal point, must occupy a position in the display (as is often the case with very small D displayed in ppm) that zero is blanked out. In this manual, we generally represent each blanked zero with the symbol 0.

3.4 PRINCIPAL TEST CONDITIONS

3.4.1 Test Frequency

Power-up frequency is 1 kHz, unless the keyboard has been locked with some other choice. There are 503 available frequencies, which can be derived using the formulas below. To select the test frequency, simply key in the desired frequency as follows, and the Digibridge will automatically obtain the nearest available one.

a. Select ENTER with the [FUNCTION] key.

b. Enter the desired frequency (always in kilohertz) and [=][SHIFT][FREQUENCY] in sequence, as follows. For example, to select 5 kHz, press:
[5][=][SHIFT][FREQUENCY]

Up to 6 digits and decimal point are valid.
For another example, if the desired frequency is 2300 Hz, key in:
[2][.][3][=][SHIFT][FREQUENCY]

The actual frequency obtained appears immediately in the LC display area. In the example of desired frequency 2300 Hz, the display is 2.3077. The actual frequency obtained is always the closest fit to your entry, one of the 503 values obtainable from the following formulas, where n is always an integer in the range indicated:

(3 kHz)(C/n) where n range is: 13...250 (freq .012000 to 0.23077)
(60 kHz)(C/n) where n range is: 4...256 (freq 0.23438 to 15.000)
(200 kHz)(C/n) where n range is: 2...13 (freq 15.385 to 100.00 kHz)

and where C = 1 + c, where c is a very small number between -.000099 and +.000099

The value of c is determined individually for each Digibridge as part of its calibration. If you want to find out what c is for your instrument, do the following. (The value will be given in ppm.)

Select ENTER with the [FUNCTION] key. Then press: [SHIFT][SPECIAL][0]

NOTE

To safeguard the calibration of c, follow this procedure exactly; if function is already ENTER, press [FUNCTION] key twice. Do NOT press any other key before "shift".

Accuracy. Test frequency is accurate to within specified tolerance of the nominal value of the selected step, i.e., within +/- .01% of (the value obtained from the three formulas above).

Indication. Frequency display is the nominal value, to 5-digit resolution. This display is shown when frequency is selected (as described above) or by interrogation as follows: select ENTER function and then press the [SHIFT][FREQUENCY] keys.

3.4.2 Test Voltage

The power-up test voltage is 1.0 volt, unless the keyboard has been locked with some other choice. There are a total of 252 choices, .005 to 1.26 V in increments of .005 V. To program the test voltage, select the ENTER function and enter the desired voltage and [=][SHIFT][VOLTAGE], as follows:

a. Select ENTER with the [FUNCTION] key.

b. For a test voltage of 750 mV, for example, enter [.][7][5][=][SHIFT][VOLTAGE].

Note: The accuracy of the programmed source voltage is:
+/- [5% + (1 + f/10kHz)]

The actual voltage across the DUT is never more than the source voltage, and depends on the DUT impedance and the source resistance (in the Digibridge) for the range in use. The DUT voltage is close to the source voltage at the high-impedance end of each measurement range and lower at the low-impedance end. Measurements near midrange are made with the DUT voltage equal to roughly 71% of the source voltage (unless the principal parameter is resistance, in which case the percentage is 50%), because the source resistance is approximately equal to the DUT impedance at midrange. Normally, the least voltage across the DUT (if its impedance is 6.25 ohms or more) will be 25% of the source voltage; this is the case for resistors measured at the low end of each range. Refer to Table 3-2 for details. (This table is similar to the table of range constants in the specifications. However, the extreme limits are given here, on ranges 1 and 4.)

Table 3-2
AUTORANGING MEASUREMENT RANGES AND SOURCE RESISTANCES

Range	Source Resistance	Principal Measured Parameter: Resistance	Capacitance	Inductance
1	102.4 kohms	max 99999 K	min .00001 pF	max 99999 H *
		mid 102 K	mid 1600 pF/f	mid 16 H/f
		min 25.6 K	max 6400 pF/f	min 4.1 H/f
2	6.4 kohms	max 25.6 K	min 6.4 nF/f	max 4100 mH/f
		mid 6.4 K	mid 25.3 nF/f	mid 1025 mH/f
		min 1.6 K	max 100. nF/f	min 256 mH/f
3	400 ohms	max 1600 ohms	min 100 nF/f	max 256 mH/f
		mid 400 ohms	mid 400 nF/f	mid 64 mH/f
		min 100 ohms	max 1600 nF/f	min 16 mH/f
4	25 ohms	max 100 ohms	min 1.6 uF/f	max 16 mH/f
		mid 25 ohms	mid 6.4 uF/f	mid 4 mH/f
		min .00001 ohm	max 99999 uF	min .00001 mH

* "K" is kilohms; "f" is test frequency in kHz.

3.4.3 Constant-Voltage Source

If it is important to measure the DUT at a particular test voltage, then select the constant-voltage feature as follows:

Press [SHIFT][CONSTANT VOLTAGE]

so that the CONSTANT VOLTAGE indicator is lit. The Digibridge now retains a source resistance of 25 ohms for all ranges. The voltage is constant for any DUT impedance significantly larger than 25 ohms. Choosing this feature causes a reduction in measurement accuracy by a factor of four, as accounted for by Kcv in the accuracy specifications. (To deselect the constant-voltage feature, press the same keys again.)

3.4.4 Constant-Current Source

To provide a constant-current source for any measurement, hold the range so that the source resistance is much larger than the DUT impedance. (See table of ranges, above.) Thus:

a. Select ENTER function with the [FUNCTION] key.

b. Hold a range as follows:
For source resistance = 102.4 kilohms (range 1): press [1][=][SHIFT][SPECIAL][1]
For source resistance = 6.4 kilohms (range 2): press [2][=][SHIFT][SPECIAL][1]
For source resistance = 400 ohms (range 3): press [3][=][SHIFT][SPECIAL][1]

c. Program the source voltage to be the product of the desired source current times the source resistance of the selected range. (Refer to paragraph 3.4.2 for programming the voltage.)

For example, if the DUT is a capacitor of nominal value near 0.4 uF, measured at about 1 kHz, its reactance is about 400 ohms. Then, hold range 2. If the desired test current is 0.1 mA, program the source voltage too be 0.1 mA times 6.4 kilohms = 0.64 V. (Note that range 1 would provide still higher source resistance, but measurements would be less accurate, as shown by the factor Cx/Cmax in the accuracy formula; see paragraph 3.6.)

3.4.5 Bias

Bias applied to the DUT (if it is a capacitor) is another test condition. Refer to paragraph 3.7.

3.5 MEASUREMENT TIME

3.5.1 General

Selection of MEASURE RATE (SLOW, MEDIUM, and FAST) obviously relates to measurement time, providing the user with an easily made choice. (The slower selections provide greater accuracy.) Programming a DELAY (typically because the normal settling time is insufficient for your particular handler) also obviously affects measurement time.

However, except for those two items, the time required to make a measurement is usually a minor concern. The user should typically pay more attention to test conditions and operating selections, some of which do affect measurement time, usually by a small amount.

In this paragraph, many items that affect measurement time will be explained.

The time required by the Digibridge to complete a measurement and display the results depends on test conditions, programmed entries, system setup, etc. The following examples are representative; the numbers are approximate.

The minimum measurement time is 36 ms (over 1600 measurements per minute).
For test frequency = 1 kHz, the minimum is 52 ms (over 1100 meas per minute).

For best accuracy (power-up conditions), the time is 1030 ms (58 meas per minute). The numbers above apply if you have the high-speed option and do NOT enable output of data via the IEEE-488 bus.
The longest single measurement cycle (including programmable delay) is about 1.7 minutes. With maximum averaging, the maximum time for final result is over 7 hours.

If you do NOT have the high-speed option: minimum is 71 ms (845 per minute); for test frequency = 1 kHz, the minimum is 87 ms (690 measurements per minute); and for best accuracy (power-up conditions), the time is 1070 ms (56 per minute).

3.5.2 Measure Rate Selection at Keyboard

Choose one of 3 basic measurement rates with the [MEASURE RATE] key: SLOW, MEDIUM, or FAST. The continuous-mode rates are respectively about 1, 4, and 11 measurements per second, if most of the test conditions and programmable selections are left at normal power-up defaults.

The tradeoff is speed vs accuracy. The Digibridge will make a more precise and accurate measurement at a slower rate. In very simplified terms, the basic accuracy is 0.02%, and the tradeoff is as follows (with the high-speed option, and frequency = 1 kHz):

SLOW rate, 0.02% accuracy, 1 measurement per second;
MEDIUM 0.05% accuracy, 4 measurements per second;
FAST rate, 0.15% accuracy, 11 measurements per second.

However, for details of accuracy, refer to the specifications. In the accuracy formulas, the effect of measure rate selection appears in the term "Ks".

3.5.3 Programmed Delay (Replaces "Settling Time")

You can program any desired delay (from 1 to 99999 milliseconds) for transient voltages to settle. The Digibridge will pause for this much time after each START signal, before actually starting to take data. (If you do not program any delay, the Digibridge will pause for a settling time of 7 ms for FAST measure rate, with test frequency = 1 kHz; slightly more for slower rates, and more or less in inverse proportion to test frequency).

In order to eliminate the settling time entirely, set delay to zero. As an example, you can set delay to 25 ms, as follows.

Select ENTER with the [FUNCTION] key and press:
[2][5][=][SHIFT][DELAY]

3.5.4 Timing Considerations for Efficient Handling and Sorting

If measurement time is important in your measurement routine, the DUTs are probably being handled and sorted rapidly, perhaps with an automatic handler, and the following topics pertain.

Select TRIGGERED mode with the [MEASURE MODE] key. This mode minimizes time between insertion of the DUT into the test fixture and beginning of measurement. Measurement starts when the Digibridge receives the START signal from the handler (or

when the START button is pressed).

Select BIN NO. with the [DISPLAY] key, if measured values are not needed. This selection saves 10 ms for each measurement, compared to other displays. Refer to paragraph 3.8 for information about bin sorting, which must be enabled before the bin-no. display will work.

Set up the handler to respond to the ACQ signal from the Digibridge, which occurs when the "data acquisition" is complete. The handler can then remove the DUT from the test fixture and replace it with another DUT.

Set up the handler to respond to the EOT signal from the Digibridge, which occurs at the "end of test", when the bin assignment is available for sorting.

If the normal settling time is insufficient for transients, program the desired delay, as explained above.

3.5.5 Integration-Time Factor (a Special Function)

The length of time that the Digibridge spends "integrating" certain analog voltages in the process of data acquisition can be varied by programming a number called the "integration-time factor", if the measure rate is selected to be FAST or MEDIUM. (The I-T factor has no effect on measurements if the measure rate is SLOW.) The I-T factor is normally 1; its range of programmability is from 0.25 to 6.

One of the requirements for the very shortest measurement time is to set the I-T factor to 0.25. To do so, as an example, press the following keys:

[.][2][5][=][SHIFT][SPECIAL][5]

The accuracy of measurement is affected. The tradeoff is illustrated as follows, for 1-kHz test frequency:

I-T factor = any value, SLOW rate, 0.02% accuracy, 1 measurement per second;
I-T factor = 1, MEDIUM rate, 0.05% accuracy, 4 measurements per second;
I-T factor = 1, FAST rate, 0.15% accuracy, 11 measurements per second.
I-T factor = 0.25, FAST rate, 0.25% accuracy, 19 measurements per second.

For details about accuracy, refer to the specifications, where the effect of programming I-T factor to be 0.25 and selecting FAST rate is designated as "maximum measurement rate" in the table of values for the term "Ks".

In addition to the straight-forward effect on measurement time that results from changing the integration time (within the process known as "data acquisition"), there is another effect (on the process known as "calculation"), as follows. Any value of I-T factor less than 1 causes the Digibridge to omit the normal mathematical correction for the short-circuit zero error. (See paragraph 3.1.3.) This correction requires about 9 milliseconds, which is a part of the difference between the 11 and 19 measurements per second mentioned above.

3.5.7 Ranges and How to Hold a Range

Descriptions of ranges, range extensions, and decimal point control are explained below.

Basic Ranges. The 4 basic ranges are numbered 1, 2, 3, 4, in order of decreasing impedance. Each basic range is approximately a factor of 16 wide. Refer to paragraph 3.4.2 for a table of ranges.

However, the word "upper" as used below refers to increasing measured value (which is the direction of increasing range number only if the principal measured parameter is capacitance). Similarly, the word "lower" as used below refers to decreasing measured value (which is the direction of decreasing range number only if the principal measured parameter is capacitance).

Extensions. Each of the 4 ranges goes beyond its basic range, with both upper and lower range extensions (also called overrange and underrange). Most of these extensions are seldom used because they overlap basic portions of other ranges. (In each case of overlap, the Digibridge will automatically select the basic range unless you select RANGE HELD.) Measurement units and multipliers in any range extension are the same as in the basic range. This constraint, together with the fact that range definition depends on frequency, cause a considerable variation in the width of range extensions. The lower limit is generally .00001, with all-zeros next; the upper limit is 99999, with all blanks next. Blanks in the measurement display are discussed below. In general, for any measurement within the specifications of the Digibridge, if a measurement can be displayed, it will be.

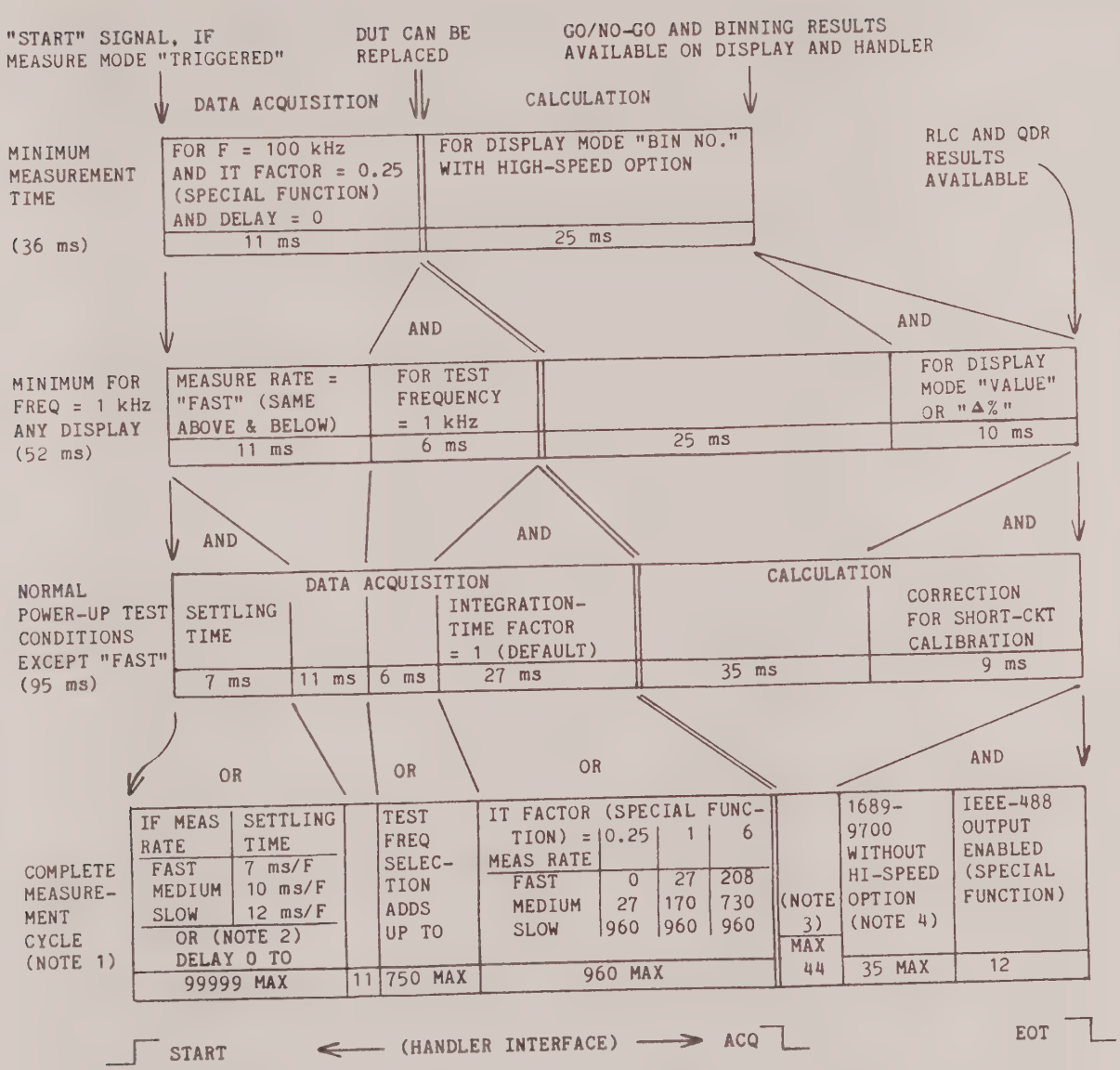
The only range extensions that are valid with autoranging are low underrange and high overrange, explained below.

Low Underrange. The "low" extension of the low range goes down to 1 count, with reduced accuracy. The smallest "1-count" increment in the display is the minimum measured value, given in the specifications in the front of this manual. Any measurement smaller than 1 count is displayed as all zeros.

High Overrange. The "high" extension of the high range goes up to the maximum display (all 9's, with the decimal point at the right), and finally to blank, with reduced accuracy. The high overrange is used for the very large values of RLC that exceed the basic high range.

Autoranging. Autoranging is normal; it is inhibited only if you select RANGE HELD. There is a slight hysteresis in the changeover from range to range to eliminate a possible cause of display flickering.

Range Holding. To inhibit autoranging, select this mode with [SHIFT][HOLD RANGE] keys, and verify that the RANGE HELD light is on. Whatever range the instrument is using for current or previous measurements will be held. The range automatically selected is the one that best fits the impedance of the DUT (not necessarily its reactance). For example, if a 50-Ω resistor is being measured when you select RANGE HELD, then the operation of the instrument is locked to the low range, Range 4, including the regularly unused overrange portion. While this range is held, you could measure a capacitor, with all the characteristics of range 4, which is the high range for C.



Note 1: The complete cycle repeats if range is not appropriate and not held. It also repeats if averaging has been programmed. The maximum time for one cycle is about 1.7 minutes and for maximum averaging, over 7 hours.
Note 2: Settling time can be 1000 ms (max) for SLOW and .012 kHz. However, if any delay is programmed, delay supercedes and replaces settling time.
Note 3: If I.T. factor < 1, the correction for short-circuit calibration is omitted, and this calculation time is 35 ms; otherwise, it is 44 ms.
Note 4: Not having the high-speed option adds 25 ms if I.T. factor < 1, 35 ms otherwise.

Figure 3- . Measurement time increments for the 1689 Digibridge depend on the measurement conditions and system selections.

3.7 BIAS FOR THE DUT

3.7.1 Internal Bias

NOTE

> Keep the EXTERNAL BIAS switch OFF and the BIAS ON indicator dark, for all measurements of inductors and resistors, and also for capacitors unless they are to be measured with dc bias applied.

To measure capacitors with the internally available 2-volt dc bias voltage applied, use the following procedure. (The FUNCTION can be either MEASURE or ENTER.)

a. Press [SHIFT][INT BIAS] keys so that the BIAS ON indicator is lit.

b. Wait at least 2 seconds before initiating measurement, to allow for settling. (In the CONTINUOUS mode, disregard displays for this interval.)

c. Wait about 20 ms after each change of DUT before initiating measurement, to allow any moderate-sized capacitor to charge. (In the CONTINUOUS mode, disregard the first display.) For very large capacitance, wait for several "time constants" RC, where R is (for example) 25 ohms on range 4 or on all ranges if the CONST VOLT indicator is lit. Source resistance is given in paragraph 3.4.2.

d. After biased measurements are completed, remove internal bias by pressing the [SHIFT][INT BIAS] keys, so that the BIAS ON indicator is NOT lit.

Notice that repeating the same keyboard sequence will cyclically enable and disable internal bias. For best results, after removing bias and before making further measurements, allow least 2 seconds for settling.

3.7.2 External Bias

Be sure that the voltage is never more than 60 V, max. Use of a current limiting voltage supply is recommended; set the limit at 200 mA, max.

Use the bias cable that is supplied. Note that it is fused.

3.7.3 Suppression of Transients

When measuring biased capacitors, the time required for settling of transients in the measuring circuitry can usually be reduced by selecting the automatic shorting routine (a special function), as follows.

Press: [2][=][SHIFT][SPECIAL][3]

However, if there is no bias, the normal routine is faster. To obtain it, press:

[0][=][SHIFT][SPECIAL][3]

3.8 BIN SORTING AND GO/NO-GO RESULTS

Refer to the condensed operating instructions on the pullout card under the Digibridge.

3.9 KEYBOARD LOCK

For this information, refer to the final manual.

3.10 OPERATION WITH A HANDLER

For this information, refer to the final manual.

3.11 SYSTEM CONNECTIONS VIA IEEE-488 BUS

For this information, refer to the final manual.

3.12 CALIBRATION

For this information, refer to the final manual.

3.13 SELF CHECKS AND FAILURE DISPLAYS (ERROR CODES)

3.13.1 Power-Up Self Check

Every time the instrument is switchd ON or the line voltage reappears after an interruption, the Digibridge keeps itself busy for a short time going through an automatic self-check routine. The RLC and QDR displays indicate in code which check is being performed. Normally these displays follow one another rapidly. However, if one of them persists, there has been a failure in the self check. The nature of the failure and the proper remedy for each are indicated below. Normal operation is inhibited in each of these cases.

88888 8888. The random-access-memory read/write exercise was imperfect. Try power-up again; otherwise the remedy is beyond the operator's control; repair service is required.

77777 XXXX. The detector test was not completed satisfactorily. Try power-up again; otherwise the remedy is beyond the operator's control; repair service is required. (The Q D R display provides some service information indicating in code which of 4 important digital signals is stuck, and whether high or low.)

66666 XXXX. The detector scale test failed. CPU will loop on failure. Switch POWER OFF and ON again. If these remedies are ineffective, repair service is required.

555 D XXXX. A signal-strength check failed. When D is 1...4, it indicates the range being checked (with voltage HIGH). When D is 5, the range is 4, with voltage LOW. CPU will loop on failure. Recycle power OFF and ON to exit from loop.

444 E XXXX. A check on test frequency and waveform failed. For E of 1, 2, 3, 4, 5, 6, the frequency being checked is 15.4, 6.0, 1.2, 0.48, .0968, .0118 kHz, respectively. CPU will loop on failure; recycle power OFF and ON to exit from loop.

33333 XXXX. PROM data checksum test. XXXX = checksum, which must be zero to pass the test.

222 F XXXX. Calibration constants test. XXXX = normalized value of constant, which must be within the limits of 1.00000 +/- 0.78125% to pass the test. For F = 0, the constant is frequency correction factor. For F = 1, 2, 3, or 4, it is the conductance of range 1, 2, 3, or 4, respectively.

This is the only power-up self-check failure that you can proceed from and operate the Digibridge. To do so, press the [C/D] key. Of course, the measured results are liable to be erroneous; you should then proceed to obtain service to repair the fault and/or recalibrate.

3.13.2 Failure Display Due to LC Resonance

A display of 22222 1111 can occur, in place of the expected L and Q, because the inductor being measured resonates with measuring circuit capacitance. (Resonance can cause an overload of the converter/detector.) The Digibridge thus presents an easily noticed failure display rather than an invalid measurement result.

When Expected. This resonance effect can be expected when large values of inductance are being measured at high frequency. In particular, if the Digibridge is autoranging, this effect can be expected in range 1 under any of the following 4 equivalent conditions. (A representative value of L that will cause selection of range 1 is indicated in parentheses beside each condition.)

1. Without extender cable, f > 3.8 kHz (L > 1 H at 4 kHz).
2. With 1688-9600 cable, f > 2.8 kHz (L > 1.3 H at 3 kHz).
3. With 1657-9600 cable, f > 1.1 kHz (L > 3 H at 1.2 kHz).
4. With any other cable and remote test fixture, use the following formula:
   f > 770 / (200 + C).

where f is in kHz, C is stray capacitance outside of the Digibridge, from the high (I+, P+) terminal to ground (guard), expressed in pF. (Measurement will be on range 1 if L > 4/f.)

This resonance effect can also be expected under some conditions of high-frequency measurement with range 1 held but the inductance of the DUT appropriate for range 2. The effect is NOT expected with autoranging in ranges 2, 3, 4, unless stray capacitance is considerably larger than that of the 1657-9600 extender cable.

It is possible for valid measurement, with a slight reduction in accuracy, to be made under conditions very close to those that will trigger the LC resonance failure display. Such a measurement can be expected to meet accuracy specifications if it is displayed at all.

Recommended Procedure. If this LC-resonance display appears, in the course of otherwise normal measurements, the instrument is functioning normally. Valid measurements can usually be made by taking one or more of the following steps.

a. If range 1 has been held, select autorange.

b. If cable and test fixture capacitance can be reduced, do so.

c. If measurement is normally in range 1, try holding range 2.

d. Reduce the measurement frequency.

e. Reduce the measurement voltage. Measurements made under this condition may be less accurate than normal, and may not meet accuracy specifications given in the front of this manual.

f. Consider the probability that (if this resonance effect is not easily avoided) the DUT may be self-resonant. If so, unqualified measurements of apparent inductance are misleading. Try a set of measurements of apparent inductance at several frequencies sufficiently low (or high) to avoid the resonance failure display. If the NEG RLC indicator is lit, the measured reactance is capacitive, although the display is a number of henries or millihenries.

3.14 SPECIAL FUNCTIONS

The following is a brief summary of the special functions and how to operate the [SPECIAL] key. Most of the special functions are described in more detail in other parts of the manual. Refer to Table 3-3.

Table 3-3
SPECIAL FUNCTIONS

Purpose	Specific Selection	Keystrokes
Setting Range	Autorange (normal)	[0][=][SHIFT][SPECIAL][1]
	Hold range 1	[1][=][SHIFT][SPECIAL][1]
	Hold range 2	[2][=][SHIFT][SPECIAL][1]
	Hold range 3	[3][=][SHIFT][SPECIAL][1]
	Hold range 4	[4][=][SHIFT][SPECIAL][1]
Output via IEEE-488 Bus	No output (max meas speed)	[0][=][SHIFT][SPECIAL][2]
	Bin numbers only	[1][=][SHIFT][SPECIAL][2]
	QDR results only	[2][=][SHIFT][SPECIAL][2]
	QDR and bin numbers	[3][=][SHIFT][SPECIAL][2]
	RLC results only	[4][=][SHIFT][SPECIAL][2]
	RLC and bin numbers	[5][=][SHIFT][SPECIAL][2]
	RLC and QDR results	[6][=][SHIFT][SPECIAL][2]
	RLC, QDR, and bin numbers	[7][=][SHIFT][SPECIAL][2]
Special Measurement Routines	Normal (fastest measurements)	[0][=][SHIFT][SPECIAL][3]
	Signal reversing (useful when test frequency coincides with power frequency)	[1][=][SHIFT][SPECIAL][3]
	Shorting in measurment circuit (useful when measuring biased capacitors)	[2][=][SHIFT][SPECIAL][3]
	Both reversing and shorting	[3][=][SHIFT][SPECIAL][3]
Digit Blanking	Elimination of "a" digits from RLC display and "b" digits from QDR display	[a.b][=][SHIFT][SPECIAL][4]
Integration-Time Factor	Multiplies integration time by factor (0.25 to 6). Normal is 1. Smaller factor decreases accuracy and measurement time. f is a number, 0.25 to 6	[f][=][SHIFT][SPECIAL][5]
Ratio Displays (RLC only)	Normal displays	[0][=][SHIFT][SPECIAL][6]
	Ratio displayed: nominal/meas value	[1][=][SHIFT][SPECIAL][6]
	Ratio displayed: meas value/nominal	[2][=][SHIFT][SPECIAL][6]
Automatic Parameter Selection	Normal, manual selection	[0][=][SHIFT][SPECIAL][7]
	Automatic selection of parameter (R/Q, L/Q, or C/D)	[1][=][SHIFT][SPECIAL][7]
Median Result	Normal, no median found	[0][=][SHIFT][SPECIAL][8]
	Display is median of 3 meas	[1][=][SHIFT][SPECIAL][8]
Version	Displays the software version	[SHIFT][SPECIAL][9]
Frequency Correction	Displays the correction "c" Refer to paragraph 3.4.1	[SHIFT][SPECIAL][0]

APPENDIX I
1689 SOFTWARE SPECIFICATION

This document is appended to the 1689 preliminary instruction manual primarily because of the information provided here about remote programming via the IEEE-488 interface. See paragraph 2.0.
(Other useful information for the user includes the following.)

The need to enter the ENTER function before using any paramater key to select range is brought out in paragraph 1.2.

Keyboard lock and unlock procedure is given in paragraph 1.3.

SOFTWARE SPECIFICATION

1689

LATEST REVISION / 03 DATE: 15 October 1982

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1.0 KEYBOARD PROGRAMMING.

1.1 The [FUNCTION] Key.

a. Purpose. The [FUNCTION] key is used to select either "MEASURE" to use the instrument to make measurements, or "ENTER" to examine and/or change programmable entries such as BIN LIMITS, TEST VOLTAGE, etc. No measurements are made while in "ENTER".

b. Press [FUNCTION] to change (alternate) between "MEASURE" and "ENTER".

1.2 Key Entries Which are Valid in Both "MEASURE" and "ENTER".

[DISPLAY] selects sequentially among "VALUE", "/\%", "BIN NO.", and "/\RLC" display modes.

"VALUE" displays the selected measurement parameter (R/Q, L/Q, C/D, C/R)

"/\%" displays the % difference between the selected measurement parameter (R, L, C) and the current "NOM.VAL".

"BIN NO." displays the bin number (0 to 14) resulting from comparison of the selected measurement parameters with the current "BIN NO." limits.

"/\RLC" displays the absolute difference between the selected measurement parameter (R, L, C) and the current "NOM.VAL".

[MEASUREMENT RATE] selects among "SLOW", "MEDIUM, and "FAST" test rates. See Product Specification for times and accuracies.

[MEASUREMENT MODE] selects between "CONT" and "TRIGGERED" measurements.

"CONT" continuously measures and displays results.

"TRIGGERED" requires a "START" command, either from the keyboard switch, the handler "START" line, or the IEEE bus. A running measurement is displayed until the number of measurements programmed in "AVERAGE" is reached.

[SHIFT] [HOLD RNG] selects (alternately) between AUTORANGE and "RANGE HELD". A display lamp indicates when in "RANGE HELD". If in AUTORANGE, the processor automatically selects the proper range when making a measurement.

[SHIFT] [CONST.V] selects (alternately) between "CONSTANT VOLTAGE" and NORMAL OPERATION. A display lamp indicates when in "CONSTANT VOLTAGE" mode. If in "CONSTANT VOLTAGE", the signal source impedance is set to the lowest value (approximately 25 ohms) and ranges are changed at different impedance values. See Product Specifications for effects of "CONSTANT VOLTAGE" on ranges and accuracy.

[SHIFT] [DQ IN PPM] selects (alternately) between "DQ IN PPM" and NORMAL DQ modes. A display lamp indicates when in "DQ IN PPM" mode. If in "DQ IN PPM" mode, the right hand display of the secondary parameter D or Q is shown in parts per million (PPM). This is equal to one million times the "NORMAL" D or Q display.

[SHIFT] [INT.BIAS] selects (alternately) between INTERNAL BIAS ON and INTERNAL BIAS OFF. A keyboard lamp indicates when "BIAS ON". When in INTERNAL BIAS ON mode, "CONSTANT VOLTAGE" is also enabled to reduce time constants. INT BIAS ON applies a D.C. -2 V bias to a capacitor under test.

[EQUIVALENT CIRCUIT] selects (alternately) between "SERIES" and "PARALLEL" equivalent circuit representation.

[Rs/Q - Rp/Q] selects the R/Q parameter. This will be "Rs/Q" if [EQUIVALENT CIRCUIT] is set to "SERIES", otherwise it will be "Rp/Q".

When in "ENTER", this also increments the range number so that units can be selected for entry purposes.

[Ls/Q - Lr/Q] selects the L/Q parameter. This will be "Ls/Q" if [EQUIVALENT CIRCUIT] is set to "SERIES", otherwise it will be "Lp/Q".

When in "ENTER", this also increments the range number so that units can be selected for entry purposes.

[Cs/D - Cp/D] selects the C/D parameter. This will be "Cs/D" if [EQUIVALENT CIRCUIT] is set to "SERIES", otherwise it will be "Cp/D".

When in "ENTER", this also increments the range number so that units can be selected for entry purposes.

[Cs/Rs - Cp/Rp] selects the C/R parameter. This will be "Cs/Rs" if [EQUIVALENT CIRCUIT] is set to "SERIES", otherwise it will be "Cp/Rp".

When in "ENTER", this also increments the range number so that units can be selected for entry purposes.

1.3 Key Entries Which are Valid Only in "MEASURE".

[1] [6] [8] [9] [=] [LOCK] selects (alternately) between keyboard LOCKED and UNLOCKED. When keyboard is LOCKED, the indicator lamps (except "BIAS ON") on the keyboard are extinguished and all other entries are ignored so that the instrument setup cannot be altered. Even if powered down, the setup conditions will be retained. Repeating the key sequence will UNLOCK the keyboard. Setup conditions will be initialized if powered down while in UNLOCKED mode.

[1] [6] [8] [9] [=] [SHIFT] [OPEN] selects (alternately) between OPEN CIRCUIT ZERO ENABLED and OPEN CIRCUIT ZERO DISABLED. When OPEN CIRCUIT ZERO ENABLED, the "MEASURE MODE" is set to "TRIGGERED" and "AVERAGE" is set to 10. The "GO" lamp is also lit as operator feedback, and a "0" appears in both displays.

[1] [6] [8] [9] [=] [SHIFT] [SHORT] selects (alternately) between SHORT CIRCUIT ZERO ENABLED and SHORT CIRCUIT ZERO DISABLED. When SHORT CIRCUIT ZERO ENABLED, the "MEASURE MODE" is set to "TRIGGERED" and "AVERAGE" is set to 10. The "GO" lamp is also lit as operator feedback, and a "5" (S) appears in both displays.

[1] [6] [8] [9] [=] [1] [SHIFT] [CALIBRATE] selects (alternately) between CALIBRATION ENABLED and CALIBRATION DISABLED. When CALIBATION ENABLED, the "MEASURE MODE" is set to "TRIGGERED" and "AVERAGE" is set to 10. The "GO" lamp is also lit as operator feedback, and a "6" appears in both displays.

1.4 Key Entries Which Are Valid Only in "ENTER".

[SHIFT] [NOM.VAL.] displays the current NOMINAL VALUE.

x [=] [SHIFT] [NOM.VAL.] sets the NOMINAL VALUE to the numerical value (x), having the units which are currently displayed. The value (x) can be up to six digits in length, plus decimal point and sign.

[SHIFT] [BIN NO.] z displays the BIN NO. z limits in the two displays. The number (z) is a two digit entry which

can be from 00 to 13.

x [=] [SHIFT] [BIN NO.] [0] [0] sets the BIN NO. 00 limits. These are the limits for the secondary (QDR) value. Q (with R), D, and Rs are upper limits. Q (with L), and Rp are lower limits. The display shows the limit, which must be entered in the units currently displayed.

x [%] y [%] [=] [SHIFT] [BIN NO.] z
sets the BIN NO. z limits. The upper limit (NOM.VAL. + x%). The lower limit is (NOM.VAL. + y%) if y [%] is entered, otherwise it defaults to (NOM.VAL. - x%). The display shows the upper and lower limits.

[SHIFT] [BIN SUM] z displays the count in the BIN SUMMARY z register. This is the number of parts which were sorted into BIN NO. z since the BIN SUMMARY was last reset.

[=] [SHIFT] [BIN SUM] [0] [0] [1] [4]
resets all bin summaries to zero (BIN SUMMARY 00 to BIN SUMMARY 14).

[SHIFT] [BIN SUM] [LOCK] sends BIN SUMMARY out to IEEE bus.

[SHIFT] [FREQUENCY] displays the currently programmed test frequency in KHz units. See Product Specification for ranges.

x [=] [SHIFT] [FREQUENCY] enters a new test frequency value. The nearest available frequency (see Product Specification) will be selected and the value shown on the display. The value is entered and displayed in KHz units.

[SHIFT] [VOLTAGE] displays the currently programmed test voltage in volts. See Product Specification for range.

x [=] [SHIFT] [VOLTAGE] enters a new test voltage value. The nearest available voltage (see Product Specification) will be selected and the value shown on the display.

[SHIFT] [AVERAGE] displays the currently programmed # of measurements to be averaged. See Product Specification for range allowed.

x [=] [SHIFT] [AVERAGE] enters a new value for the # of measurements to be averaged. The entered value is converted to an integer and displayed.

[SHIFT] [DELAY] displays the currently programmed measurement

	settling delay in milliseconds. See Product Specification for range.
x [=] [SHIFT] [DELAY]	enters a new value for the measurement settling delay in milliseconds. The entered value is converted to an integer and displayed.
[SHIFT] [SPECIAL] z	displays the currently programmed value of the special function number (z).
x [=] [SHIFT] [SPECIAL] z	enters a new value (x) for special function number (z).

Purpose	Special # (z)	Entered Value (x)	Description
Frequency Correction	0	x	This is the deviation of the oscillator frequency from its nominal value. Allowed entry range is -99 ppm to +99 ppm. After entry, [1] [6] [8] [9] must be entered to allow the value to be altered, otherwise it remains unchanged.
Range Set	1	0	Set to Autorange
		1	Hold Range #1
		2	Hold Range #2
		3	Hold Range #3
		4	Hold Range #4
IEEE Output Selection	2	0	No Output (Highest Speed)
		1	Bin No.
		2	QDR
		3	QDR, Bin No.
		4	RLC
		5	RLC, Bin No.
		6	RLC, QDR
		7	RLC, QDR, Bin No.
Measurement Routines	3	0	Normal Routine (Highest Speed)
		1	Signal Reversed
		2	Shorting Procedure (Use w/Bias)
		3	Signal Reversed, Shorting Procedures

Purpose	Special # (z)	Entered Value (x)	Description
Digit Blanking	4	a.b	Eliminates (a) digits from RLC display, eliminates (b) digits from QDR display.
Integration Time	5	x	For medium and fast speeds, multiplies the integration time by any value (x), ranging from (0.25 to 6.0) resulting in higher or lower than normal test speed and accuracy. The default is 1.
Ratio Displays (RLC)	6	0 1 2	Normal RLC Display Display Nominal Value/RLC Value Display RLC Value/Nominal Value
Automatic Parameter Selection	7	0 1	Normal Operation Automatically Select R/Q, L/Q, C/D Parameter
Median Value Selection	8	0 1	Normal Operation Median Value of 3 Measurements
Version Number	9	N/A	Displays Program Version Number (Read Only)

1.5 The [EXTERNAL BIAS] Switch.

[ON] Inserts the external bias supply in series with the test signal source lead. Note that a bias supply must be connected to the rear jack in order to apply a test signal to the device under test. The "BIAS ON" lamp will glow dimly indicating EXTERNAL BIAS ON. When a bias voltage is applied, the lamp will glow more brightly. In this mode, the measurement hardware is forced to CONSTANT VOLTAGE to avoid time constant delay problems.

[OFF] Removes the external bias supply from the measurement circuit.

2.0 REMOTE (IEEE BUS) PROGRAMMING.

2.1 Table of IEEE Command Entries.

Category	Selection	Type	Command
Display	Bin #	2 byte	D0
	Delta %	2 byte	D1
	Value	2 byte	D2
	Delta RLC	2 byte	D3
	Ratio: Nominal Value/RLC Value	2 byte	D4
	Ratio: RLC Value/Nominal Value	2 byte	D5
	Bin On Ratio: Nominal Value/RLC Value	2 byte	D6
	Bin On Ratio: RLC Value/ Nominal Value	2 byte	D7
Measurement Rate	Fast	2 byte	S0
	Medium	2 byte	S1
	Slow	2 byte	S2
Measurement Voltage	Constant, off	2 byte	Y0
	Constant, on	2 byte	Y1
	Value (in volts) = V	Floating Point	Vv;
Function	Measure	2 byte	P0
	Enter	2 byte	P1
Measurement Mode	Triggered	2 byte	T0
	Continuous	2 byte	T1
	Triggered Median Value	2 byte	T2
	Continuous Median Value	2 byte	T3
Parameter	Inductance (L/Q)	2 byte	M0
	Capacitance (C/D)	2 byte	M1
	Capacitance (C/R)	2 byte	M2
	Resistance (R/Q)	2 byte	M3
	Inductance (L/Q) ppm	2 byte	M4
	Capacitance (C/D) ppm	2 byte	M5
	Capacitance (C/R)	2 byte	M6
	Resistance (R/Q) ppm	2 byte	M7
	Automatic Selection of R/Q, C/D, L/Q	2 byte	M8
Equivalent Circuit	Parallel	2 byte	C0
	Series	2 byte	C1

Category	Selection	Type	Command
Range Control	Hold range	2 byte	R0
	Hold range 1	2 byte	R1
	Hold range 2	2 byte	R2
	Hold range 3	2 byte	R3
	Hold range 4	2 byte	R4
	Autorange	2 byte	R5
Frequency	Value (in KHz) = f	Floating Point	Ff;
Zero Calibration	Disable	2 byte	Z0
	Enable open	2 byte	Z1
	Enable short	2 byte	Z2
Data Output	None	2 byte	X0
	Bin #	2 byte	X1
	QDR	2 byte	X2
	QDR, Bin #	2 byte	X3
	RLC	2 byte	X4
	RLC, Bin #	2 byte	X5
	RLC, QDR	2 byte	X6
	RLC, QDR, Bin #	2 byte	X7
Limit Entry	Bin #	3 byte	Bbb
	Nominal Value (in Ohms Henries, Farads) = n	Floating Point	Nn;
	High limit (in%=h)	Floating Point	Hh;
	Low limit (in%=l)	Floating Point	Ll;
Initiation	Start a measurement (like start switch)	2 byte	G0
Manual Start	Enable switch	2 byte	W0
	Disable switch	2 byte	W1
Keyboard Lock	Unlock	2 byte	K0
	Lock	2 byte	K1
Average	# of measurements = a	Floating Point	Aa;
Internal Bias	Off	2 byte	U0
	On	2 byte	U1
Bin Summary	Disable output	2 byte	E0
	Enable output	2 byte	E1
	Reset bin summary to 0	2 byte	E2

Category	Selection	Type	Command
Measurement Routines	Normal routine (highest speed)	2 byte	Q0
	Signal reversal (use for low frequency hum rej.)	2 byte	Q1
	Shorting between measurements (for Bias, charged cap.)	2 byte	Q2
	Signal reversal and shorting between measurements	2 byte	Q3
Display Digit Blanking	Eliminate (a) digits from RLC, (b) digits from QDR	3 byte	Oab
Integration Time Multiplier	Value multiplies Medium and Fast Integration Time	Floating Point	Ii;

2.2 Two Byte and Three Byte Entries.

Entries (from table, above) having a "2 byte" or "3 byte" type are simple ASCII character sequences of two or three characters. The first character is a CAPITAL letter which designates the category of the entry. The following one or two ASCII characters are numbers (0 to 9) which select within the category. For example, the ASCII sequence CHARACTER D followed by CHARACTER 2 (shown as D2) selects the VALUE display.

2.3 Floating Point Entries.

Entries (from table, above) having a "Floating Point" type consist of an ASCII character sequence of arbitrary length. The first character is a CAPITAL letter which designates the category of the entry. The following character sequence may contain (+, -, e, E, 0 ... 9) representing a floating point number. e or E is used for E-format entries. The character sequence is terminated by a semicolon (;). Space characters are ignored. For example:

```
F0.1;       <---+
F1E-1;      <----\
F100.0E-3; <-----\
                 +- all set the frequency to 100 Hz (0.1 kHz)
```

2.4 Output Formats – RLC, QDR, BIN NO.

The Digibridge sends data to the IEEE bus at the completion of a measurement sequence. These outputs which were enabled prior to the start of the measurement will be sent to the IEEE bus. Outputs for RLC, QDR, and BIN NO. can be enabled by either SPECIAL FUNCTION #2 from the keyboard or the XO...X7 command from the IEEE bus.

The character string for RLC value has the length of 17 characters; for QDR value, 17 characters; for BIN NUMBER, 10 characters, including spaces, carriage return, and line feed characters.

RLC-VALUE DATA OUTPUT FORMAT

Character Sequence	Purpose	Allowed Characters	Meaning
1	Status	(space)	Normal operation, measurement on a basic range
		U	Underrange held (reduced accuracy)*
		O	Overrange held (reduced accuracy)*
		E	End extension of range 1 or 4 (reduced accuracy)**
		I	Invalid measurement due to signal overload
2	/\RLC Mode	(space)	Normal Display
	Ratio Mode	^	/\RLC Mode
		/	Ratio Mode: Nominal Value/RLC Value
3	Parameter	L	Inductance
		C	Capacitance
		R	Resistance
4	Ratio Mode	(space)	Normal Display
		/	Ratio Mode: RLC Value/Nominal Value
5,6	Units	(space)H	Henries
		mH	Millihenries
		uF	Microfarads
		nF	Nanofarads
		pF	Picofarads
		(space)%	Percent difference from nominal value
		(space)O	Ohms
		KO	Kilohms
7	Format	(space)	
8	Sign	(space)	Positive R,L,C, /\RLC, or % diff
			Negative R,L,C, /\RLC, or % diff
9...15	Number	012345 6789. (space)	Measured number, right justified in format field; like the LC display except the zero before the decimal point is explicitly provided and this number can be as long as seven characters.
16		(CR)	The standard "carriage return" and
17	Delimiter	(LF)	"line feed" characters; end of string.

* Underrange (overrange) for measurements with "non constant voltage" if DUT impedance is equal to that of an R, L or C too small (large) for the basic portion of the range being held, and if a range change is possible to improve accuracy. Similarly, for CONSTANT voltage if the DUT impedance is outside the basic portion (of the range being held) scaled up by a factor of four, i.e., the impedance less than that at the midpoint of the basic rane or greater than four times its high impedance end.

** Range 1 end extension if DUT impedance exceeds that of the largest R or L (smallest C) in basic range 1. Range 4 end extension if DUT impedance is less than that of the smallest R or L (largest C) in basic range 4. No possibility of changing range to improve accuracy.

QDR-VALUE DATA OUTPUT FORMAT

Character Sequence	Purpose	Allowed Characters	Meaning
1	Status	(space)	Normal operation
		0	Overrange of QDR display
		I	Invalid measurement due to signal overload
2	Format	(space)	
3	Parameter	Q	Quality factor
		D	Dissipation factor
		R	Resistance
4	Format	(space)	
5...7	Units	(2 spaces)Ω	Ohms
		(space)kΩ	Kilohms
		ppm	Parts per million (for D or Q)
		(3 spaces)	Dimensionless (for Q or D)
8	Format	(space)	
9	Sign	(space)	Positive QDR value
		-	Negative QDR value
10...15	Number	012345 6789. (space)	Measured number, right justified in format field; like the QDR display except the zero before the decimal point is explicitly provided and this number can be as long as six characters.
16		(CR)	The standard "carriage return" and
17	Delimiter	(LF)	"line feed" characters; end of string.

BIN NUMBER DATA OUTPUT FORMAT

Character Sequence	Purpose	Allowed Characters	Meaning
1	Pass/fail	(space) F	Go (bins 01 through 13) No-Go (bins 00 or 14)
2	Format	(space)	
3 4 5	Label	B I N	The word "BIN".
6	Format	(space)	
7,8	Category	01234 56789	Bin number assignment, 00 to 14.
9 10	Delimiter	(CR) (LF)	The standard "carriage return" and "line feed" characters; end of string.

2.5 Serial Poll - Status Byte.

Status. The Digibridge responds with a status byte when the bus is in the serial poll mode and the Digibridge is addressed to talk. The status is encoded as shown in the Table and sent on the data lines DI01 through DI08.

STATUS CODE

Line	Significance of a "1"	Significance of a "0"
DI08	Remote.	Local.
DI07	Request for service, RQS. (This device asserted SRQ)	No request by this Digibridge for service.
DI06	Recalibration required.	Normal operation.
DI05	Busy, measurement in process.	Measurement completed.
DI04	Limits were tested.	Limits were not tested.
DI03	RLC measured value is available.	RLC value is not available.
DI02	QDR measured value is available.	QDR value is not available.
DI01	Bin No. assignment is available.	Bin No. assigment is not available.

2.6 Programming Guidelines.

If the Digibridge is to be programmed (TALK switch set to TALK/LISTEN), keep the following suggestions in mind.

1. An "unlisten" command is required before measurement is possible.

2. If not addressed to talk, the Digibridge sends a service request (SRQ low) when it has data ready to send.

3. Then SRQ will not go false (high) until the Digibridge has been addressed to talk or has been serially polled. A typical program might include these features:

   * Initial Setup: with ATN true, "untalk unlisten, my listen address (of Digibridge), my talk address (of CPU)"; then with ATN false, measurement conditions.

   * Measurement Enabling Sequence, for example: untalk the Digibridge, send a GET, unlisten the Digibridge.

   * After the CPU receives the SRQ, necessary enabling of data transfer: with ATN true, "untalk, listen, my listen address (of CPU), my talk address (of Digibridge)"; then ATN false.

2.7 Bin Summary Output Format.

The Bin Summary Output can be enabled by either the [SHIFT] [BIN SUM] [LOCK] sequence from the keyboard or the E1 command from the IEEE bus.

The Bin Summary Output consists of 15 lines for the 15 bins (00 through 14). Each line has the following format:

BIN SUMMARY DATA OUTPUT FORMAT

Character Sequence	Purpose	Allowed Characters	Meaning
1	Pass/fail	(space) F	Go (bins 01 through 13) No-Go (bins 00 or 14)
2	Format	(space)	
3 4 5 6 7 8	Label	B I N S U M	The word "BINSUM".
9	Format	(space)	
10, 11	Category	01234 56789	Bin Summary Number, 00 to 14.
12	Equivalence	=	Equals
13-17	Total	01234 56789	Total number counted in this Bin Summary Number.
18 19	Delimiter	(CR) (LF)	The standard "carriage return" and "line feed" characters; end of string.

3.0 DIAGNOSTIC AND ERROR SIGNALS.

3.1 Power Up Self-Check.

a. Purpose. The power up self-check performs a sequence of measurements in order to test the operation of the Digibridge.

b. Description. When power is applied, the Digibridge runs through the self-check sequence in order. Particular diagnostic displays can be held by pressing and holding any key on the keyboard. If no key is pressed, the sequence will continue. The sequence will hang up on failure.

c. Sequence. The sequence of the self check is as follows:

88888 8888 RAM Read/Write Test

77777 xxxx Detector Test
xxxx = 7777: DBIG is stuck low
xxxx = 6666: DMSR is stuck high
xxxx = 5555: FCOUNT is not toggling
xxxx = 3333: DMSR is stuck low
xxxx = 2222: CMP-L is stuck high
xxxx = 1111: DBIG is stuck high

66666 xxxx Detector Scale Factor Test (f=1 kHz, level=75 mV)
xxxx = normalized value (limits=0.875 to 1.125)

555 D xxxx Signal Strength Test (f=1 kHz)
xxxx = normalized value (limits=0.25 to 1.0)
D=5: Range #4, Voltage = 75 mV RMS
D=4: Range #4, Voltage = 1.275 V RMS
D=3: Range #3, Voltage = 1.275 V RMS
D=2: Range #2, Voltage = 1.275 V RMS
D=1: Range #1, Voltage = 1.275 V RMS

444 E xxxx Frequency + Level Test
xxxx = normalized value (limits=0.25 + 1.0)
E=6: 15.4 kHz
E=5: 6.0 kHz
E=4: 1.2 kHz
E=3: 0.48 kHz
E=2: 0.0968 kHz
E=1: 0.0118 kHz

33333 xxxx PROM Data Checksum Test
xxxx = checksum (must equal zero)

222 F xxxx Calibration Constants Test
xxxx = normalized value (limits=1.0 +/- 0.78125)
F=4: Range 4 Conductance
F=3: Range 3 Conductance
F=2: Range 2 Conductance
F=1: Range 1 Conductance
F=0: Frequency Correction Factor

NOTE

The last test sequence (222 F xxxx) is a non-catastophic failure, so that the operator can continue by pressing the [C/D] key. However, the faulty calibration must be corrected to prevent erroneous results.

3.2 Signal Overload Errors.

0 14 Indicates that an unrecoverable signal overload has occurred during the last measurement. This means that a signal overload occurred while in "Range Hold" or while on Range 4.

If a signal overload occurs on ranges 1, 2, or 3 and "Range Hold" is disabled, the Digibridge will range up one range and try again. It will not display the error message in this case.

Signal overload can result from:

a. "Range Hold" and "Constant Voltage" with too low an impedance value for the range.

b. Charged capacitor transient.

c. Transient due to application of bias voltage.

d. Hardware failure.

e. LC resonance effect (measuring L).

3.3 Converter/Detector Malfunction Errors.

22222 xxxx Converter/Detector malfunctioning during a measurement, which is aborted.
xxxx = 2222: Measure cycle is too long.
xxxx = 1111: Measure cycle is too short (never happens).

APPENDIX II
1689 HANDLER INTERFACE INFORMATION

This portion of the future section 2 of the manual is appended to the 1689 preliminary instruction manual to provide information about the connection and use of the Digibridge with an automatic component handler.

Notice that automatic sorting into bins 8 through 13 is not feasible with the 1658-9610 IEEE-488 Bus / Handler Interface Card, although the Digibridge will display all bin results. The 1689-9610 High-Speed Measurement Option includes the capability to sort automatically into all of the bins.

2.7 HANDLER INTERFACE (OPTIONAL).

2.7.1 Interface via High-Speed Measurement / Interface Option (1689-9610)

If you have the high-speed measurement / interface option, connect from the HANDLER INTERFACE on the rear panel to a handler, printer, or other suitable peripheral equipment as follows. (The presence of the 24-pin connectors on the rear panel verifies that you have one or other of the interface options; see also paragraph 2.7.2.) The appropriate connector to use in making a cable is Amphenol 57-30240. Refer to Table 2-1 for the key to signal names, functions, and pin numbers.

As indicated in the Specifications at the front of this manual, the output signals come from open-collector drivers that pull each signal line to a low voltage when that signal is active and let it float when inactive. Each external circuit must be powered by a positive voltage, up to 15 V (max), with sufficient impedance to limit the active-signal (logic low) current to 24 mA (max).

CAUTION

Provide protection from voltage spikes over 15 V.

The cautionary note above means typically that each relay or other inductive load requires a rectifier across it (cathode connected to the power-supply end of the load).

The input signal is also active low and also requires a positive-voltage external circuit, which must pull the signal line down below 0.4 V, but not less than 0.0 V, i.e., not negative. The logic-low current is 0.4 mA (max). For the inactive state (logic high), the external circuit must pull the signal line above +2.5 V, but not above +5 V.

Table 2-1
HANDLER INTERFACE KEY

Signal Name	1689-* Pin No.	1658-* Pin No.	Function (All signals "active low")
		DC CONNECTIONS:	
-----	5, 6, 7	5, 6, 7	Ground connection.
-----	10	10	DC bus (+5 V) available; see note **
		INPUT:	
START	1	1	Initiates measurement (single or avg).
		OUTPUTS:	
EOT	18	18	"End of test"; bin signals are valid.
ACQ OVER	22	22	"Data acquisition over"; DUT removal OK.
BIN 0	15	15	No-go because of D or Q limit.
BIN 1	17	17	Go, bin 1.
BIN 2	19	19	Go, bin 2.
BIN 3	21	21	Go, bin 3.
BIN 4	23	23	Go, bin 4.
BIN 5	14	14	Go, bin 5.
BIN 6	16	16	Go, bin 6.
BIN 7	20	20	Go, bin 7.
BIN 8	24	-----	Go, bin 8.
BIN 9	2	-----	Go, bin 9.
BIN 10	3	-----	Go, bin 10.
BIN 11	4	-----	Go, bin 11.
BIN 12	8	-----	Go, bin 12.
BIN 13	9	-----	Go, bin 13.
BIN 14	13	-----	RLC fail, no-go by default (suits no other bin).
OTHER PASS	-----	24	Go, eighth bin, for 1689 bins 8,9,10,11,12,13.
RLC FAIL	-----	13	Ninth bin, no-go by default (1689 bin 14).

* Interface plug-in options: 1689-9610 and 1658-9610.
** Low-power dc bus (+5 V) available for systems use, commonly for opto-couplers. CAUTION: limit the load to 25 mA, max. To obtain this voltage, the service technician must install a wire jumper, on the interface board, at WT 2 to WT 3.

2.7.2 Interface via IEEE-488 Bus / Handler Interface Card (1658-9610)

If you have the 1658-9610 interface option, connect from the HANDLER INTERFACE on the rear panel to a handler, printer, or other suitable peripheral equipment as follows. (The presence of the 24-pin connectors on the rear panel verifies that you have one or other of the interface options; see also paragraph 2.7.1.) The appropriate connector to use in making a cable is Amphenol 57-30240. Refer to Table 2-1 for the key to signal names, functions, and pin numbers.

As indicated in the Specifications at the front of this manual, the output signals come from open-collector drivers that pull each signal line to a low voltage when that signal is active and let it float when inactive. Each external circuit must be powered by a positive voltage, up to 30 V (max), with sufficient impedance to limit the active-signal (logic low) current to 16 mA (max).

CAUTION

Provide protection from voltage spikes over 30 V.

The cautionary note above means typically that each relay or other inductive load requires a rectifier across it (cathode connected to the power-supply end of the load).

The input signal is also active low and also requires a positive-voltage external circuit, which must pull the signal line down below 0.4 V, but not less than 0.0 V, i.e., not negative. The logic-low current is 0.4 mA (max). For the inactive state (logic high), the external circuit must pull the signal line above +2.5 V, but not above +5 V.

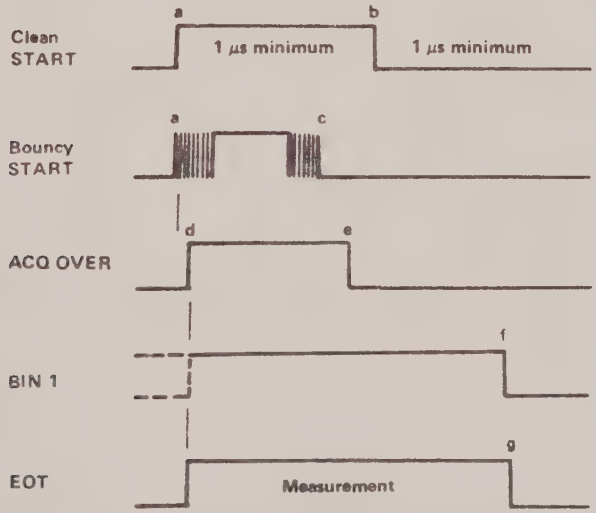

Figure 2-3. Handler interface timing diagram. External circuitry must keep b-a > 1 μs, and (if START is not "debounced") a-c < 5 ms. The DUT can be disconnected after "e" unless the measure mode is AVERAGE, in which case ACQ OVER goes low for 50 ms and then high again for each of the supplementary measurements. The selected "BIN" line goes low at "f"; the others stay high.

2.7.3 Timing

Figure 2-3

Refer to the accompanying figure for timing guidelines. Notice that START must have a duration of 1 us (minimum) in each state (high and low). If START is provided by a mechanical switch without debounce circuitry, the Digibridge will make many false starts; if START does not settle down (low) within 5 ms (maximum) of the first transition to high, the measurement time may increase substantially.

Measurement starts at time d, which is essentially the same as time b or c; measurement is completed at e. (The START signals are expanded for clarity.) During the calculation interval d-e, the DUT must remain connected, for data acquisition. After interval e-f, measurement results are available for sorting, i.e., one of the BIN lines goes low. A few micro-seconds later, EOT goes low (can be used to set a latch holding the bin assignment). ACQ OVER, the selected BIN line, and EOT then stay low until the next start command.

Be sure the TALK switch is set to TALK ONLY, if the IEEE-488 bus is not used.

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